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Devoted to the Advancement of Scientific Metallurgy

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The Flow of Metal in Molds
GEORGE M. ENOS

Magnesium and Its Alloys in Aircraft
H. G. HARVEY

Automatic Temperatute Control in Chromium Plating
R. W. SAUNDERS

Protecting Iron during Acid Pickling
U. R. EVANS and J. STOCKDALE

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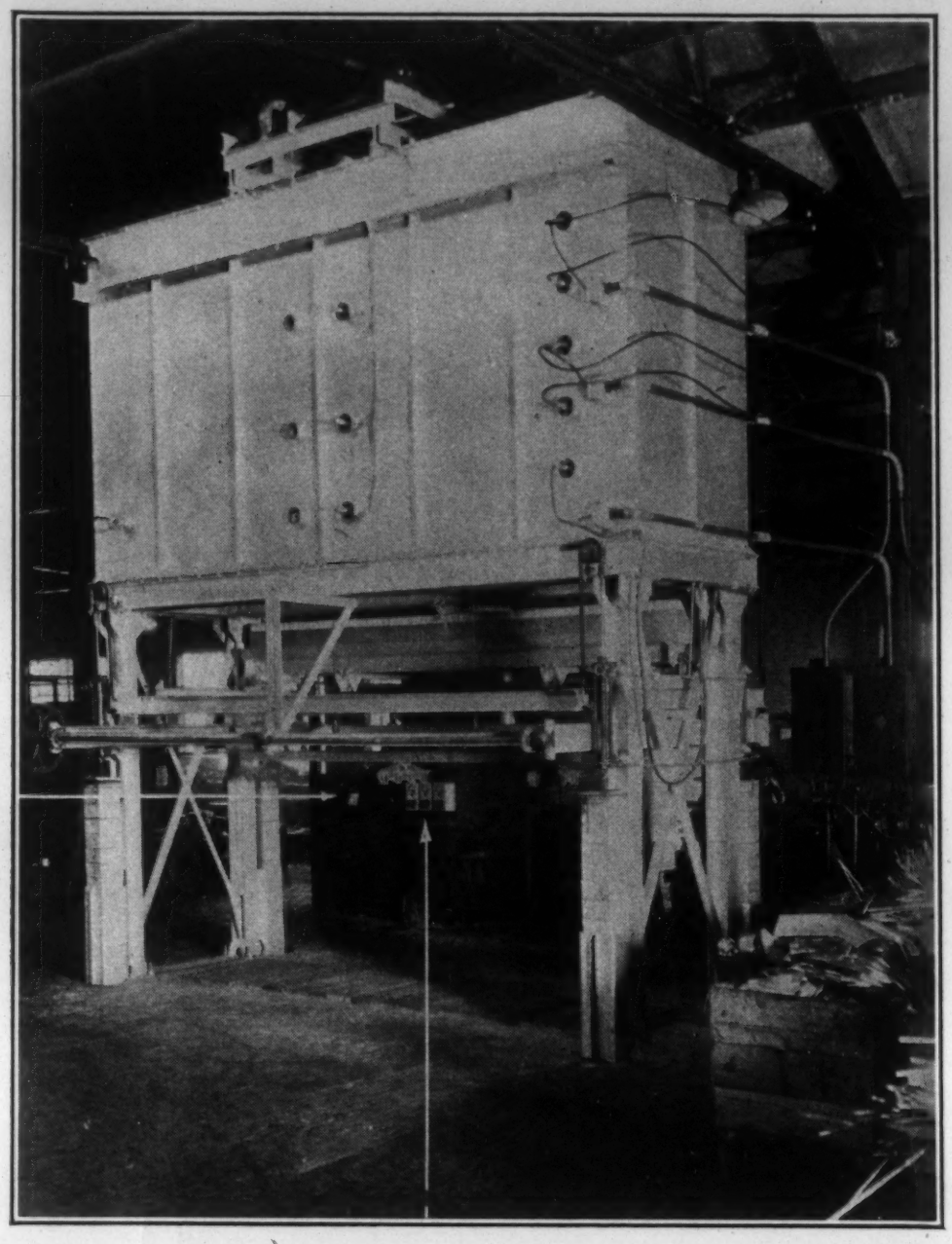

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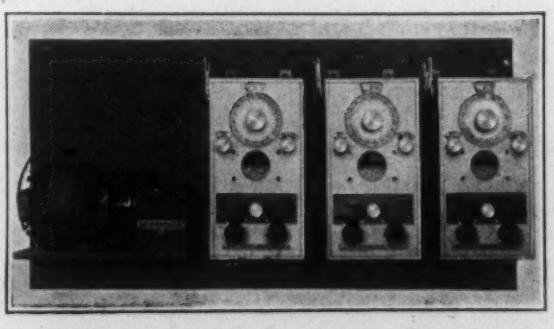

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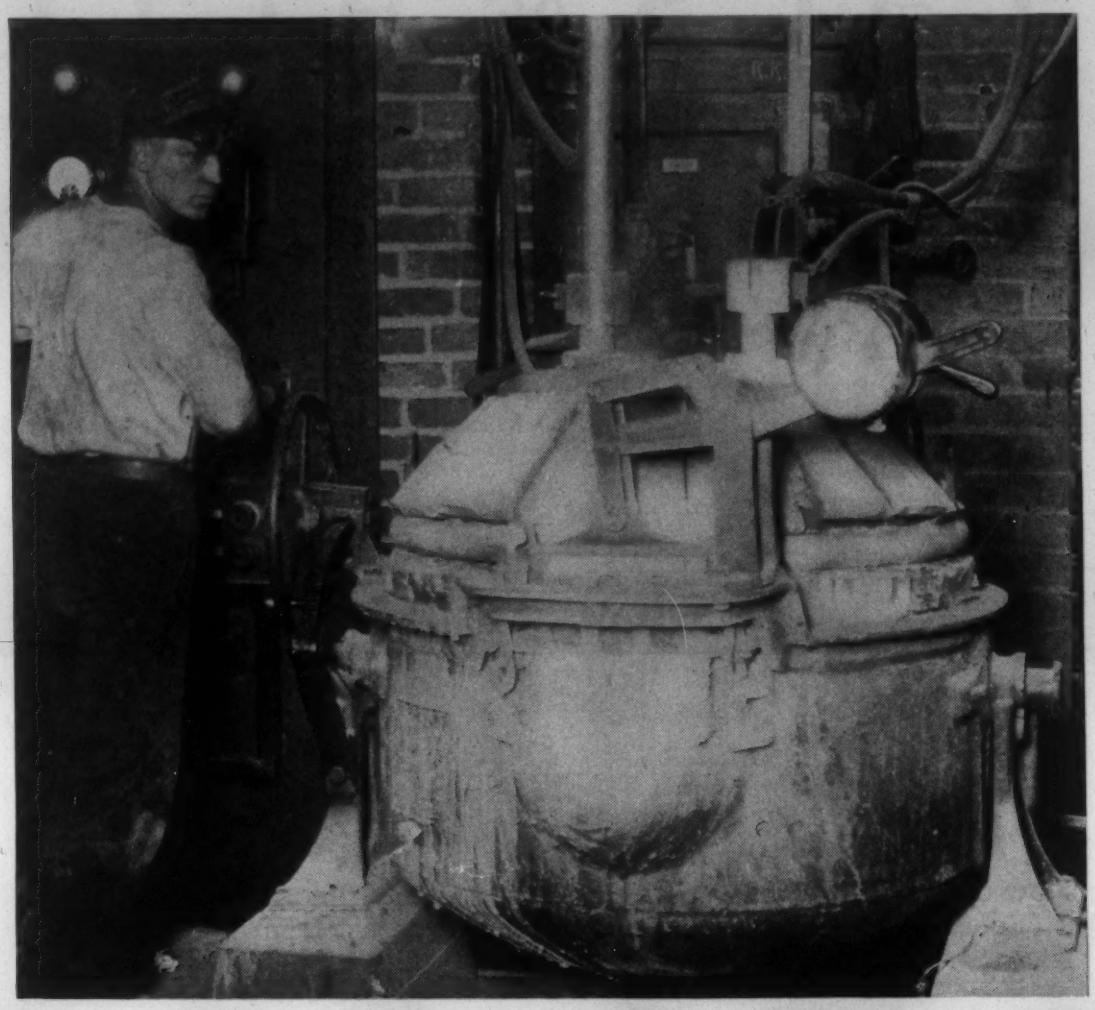

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PUBLISHER'S PAGE

Note— On this page the publishers will talk right straight to you each month. We will tell you how things are progressing with METALS & ALLOYS. *We will undoubtedly ask your advice on many points. We are publishing this paper not primarily to please ourselves but rather to serve you. And our office door is always open. You are invited to call.*

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We are still able to start a limited number of subscriptions with the first issue, or, of course, a subscription could be started with the January number.

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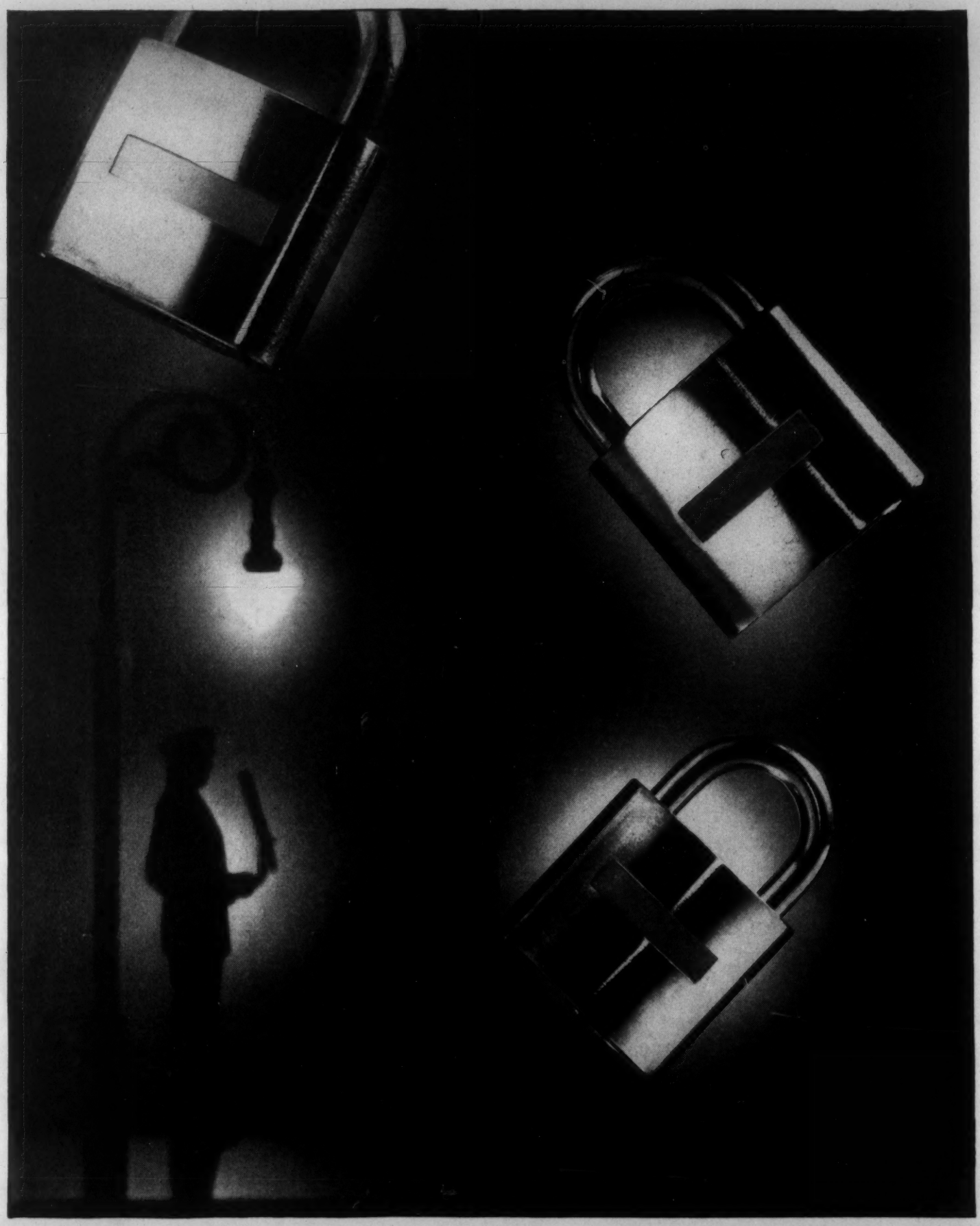

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Editorial Comment

In this department I try to comment on metallurgical and allied matters that seem to me interesting and significant. The views expressed reflect my own personal attitude. Many of our readers will have ideas of their own on these subjects and are urged to contribute them in the form of letters which will gladly be published in succeeding issues.—H. W. GILLETT, *Editorial Director.*

Heresy

We are often told that the foundation of our industrial development is the American patent system, which fosters invention and protects the poor inventor against the unscrupulous and rapacious corporation that would otherwise steal his invention. Since the patent system exists, and we can only guess what might happen in its absence, no one can disprove the statement. Property values do exist in patents, and we admit that, things being as they are, it would be practically impossible to get the country to agree to abolish the patent system, and jeopardize those property values.

We wonder though, whether it would not be in the public interest to commandeer all patents, set up a tribunal to appraise their value, if any, pay the owners from the public purse, and abolish the patent system. With anyone free to make anything, the man who made it the best and cheapest would get the business. Would that not be in the public interest? In industries like the automobile and the radio, it has been found that pooling of patents is the only way the industries can advance, and it would appear that this brings about a situation very closely analogous to that which would exist if there were no patents.

Would aircraft inventions cease to be made if the inventors could not get patents? We don't think so. The argument that the patent system fosters invention, may be, for all anyone knows, a *post hoc propter hoc* fallacy.

Increasing numbers of firms take out patents, not with any idea of ever prosecuting infringers, but merely to protect themselves against a patent hold-up by others. They acquire patents at prices that are only justified in comparison with the high cost of patent litigation. Many patents have a nuisance value only.

Many really important discoveries, the sum total of the results of the work of many different investigators, are so balled up by the patent situation, that instead of being put to immediate public service, the new product must worry along till it is obvious that its general use cannot be longer delayed, and that its value will make up for the necessity of buying or fighting patents. Would not the high chromium steels have found far more rapid use had the patent situation been less involved? If the various inventors had taken their ideas to producers of steel, and joined their technical staffs to develop the ideas, would not the sum total of profits have been greater and would not the recompense to the inventors have been as much and as justly distributed as is the case with the present system? What benefit to mankind has the granting of patents on chromium plating been?

We recall one metallurgical patent which was adjudged basic by the courts. The firm that owned it itself produced some of the alloy covered by the patent, in a very leisurely, old-fashioned way, but made most of its profits through royalties on production by others. The public could use the product only under irksome restrictions, and got along without it as much as it could. When the patent expired, active competition started, and in order to make any money after royalties ceased to come in, the firm that had controlled the patent had to wake up. Since it knew rather more about the product than its competitors did, it was able, when it once had to bestir itself, to produce economically, and to improve the quality at a far more rapid rate than it had done during the life of the patent. It is now making more profits than it ever did while it held the monopoly.

We recall another metallurgical patent covering all alloys of a common and of a rarer metal. This was taken out at a time when certainly but a few grams of the rarer metal were

Photograph Dorr News Service

Mural Panel "Where Vulcan Reigns" By Aldo Lazzarini, for the S.S. Pennsylvania

available to the inventor, and, if indeed the whole thing was not a paper invention pure and simple, he could not have adequately determined the properties of the alloys high in the rarer metal. If that patent is valid, it is basic, and the fear that it is valid has prevented needed work being done on that alloy system.

There are "metallurgists" who watch for a growing interest in a group of alloys with which they have done no real work, study the existing patents, plot out the compositions covered, and apply for patents on the gaps in composition that have not been covered, in the hope that sometime someone who is really doing work, will find something useful within that gap, when they plan to step forward and collect.

If some census could be taken that would show the value of the time and effort put forth by technical staffs, by patent attorneys and by the courts, in clearing up or avoiding patent difficulties, there would be a big debit against the credit claimed by the supporters of our patent system. We class all this expense as non-productive, and we wonder whether the expense of the Patent Office itself may really be classed as productive.

If each patent application could be so thoroughly studied, and the process or product so tested before the patent were granted that its status would be as definite when it was once granted as if it had been adjudicated all along the line of appeals through the highest courts, the patent system would lose much of its evil, for it is the uncertainty whether a patent is valid that creates the most irritating situations. But, since scarcely one patent in a thousand has value that would justify this attention, the cost of such a method would probably be no less than the present one in which the facts are determined afterward in a few cases instead of beforehand in all.

At the end of his sophomore year, an average college student can pass the Civil Service examination, and get an appointment on the Patent Office examining staff. As soon as they get fairly competent, most of them quit, and set up as patent attorneys. With cubs forming the bulk of the staff, it is a wonder that the Patent Office does as well as it does. Many editorials have been written urging a larger and better paid staff for the Patent Office, and much thought has been given to methods and means of improving the Patent Office. Few seem to have speculated openly on what would happen were the whole patent system abolished. It is heresy to suggest it; we know it won't be done in our life-time, and we shall doubtless ourselves continue to utilize the existing system if and when we think of anything that seems worth patenting. We expect that the list of metallurgical patents in METALS & ALLOYS will increase in length month by month.

But we wish some Einstein could tell us what the result would be if whatever is of value in the increasing mass of patents were either published as scientific information for free use, or held secret but put into practice, instead of either lying dormant or causing litigation.

The man who defined a patent as an "invitation to litigation" wasn't so far off. The more we see of metallurgical patents, the less respect we have for inventors as a class, and the more respect we have for those who are willing to fight to break down a patent which they do not believe represents a real and valid invention. We used to accept the theory that the poor inventor needed and deserved all the protection Uncle Sam could give him, but after seeing the struggles of some firms to keep from paying tribute to "inventors" who have been able to secure a patent on something these firms have been using, which in no wise sprung from the outside "inventor's" brain, and which was so obviously the next step that no one "skilled in the art" would have thought to patent it, we think there are two sides to the question.

We believe that by and large, American business would deal fairly with inventors if there were no patents. Is it not possible that the inventors themselves would be as well off without a patent system? We feel pretty sure the public would be. There may have been a stage in American development when the patent system was necessary to stimulate invention. Even if so, is that stimulus still needed? If not, why retain it?

We know of no experiment that would be more interesting than to find out what would happen in the absence of the patent system. Of course, there is no experiment less likely to be tried. The trouble is that everyone admits that the system is far from perfect, but there seems to be no practicable way to improve it very much, and still retain it.

To the Editor of METALS & ALLOYS:

Dear Sir: I am sure there are many metallurgists who have been unaware of the extent of the work done in X-ray metallography, and the importance of the achievements. In my own case, Prof. Clark's article has changed a mild curiosity in the subject into a really keen interest. It is my hope that METALS & ALLOYS will maintain its offerings on the same high scientific plane as that evidenced by this article on X-ray Metallography.

Yours very truly,

H. H. BLEAKNEY

Pittsburgh Crucible Steel Company,
Midland, Pa.

American Institute of Mining and Metallurgical Engineers

New York, February 17–20, 1930

The Annual Business Meeting of the Institute will be held Tuesday morning. The program has been so arranged that no sessions for members conflict with it and ample opportunity will be afforded to discuss any phase of Institute activities. The Women's Auxiliary meets Tuesday morning and afternoon. On Tuesday afternoon the Petroleum Division holds a general meeting on Unit Operation at which it is anticipated there will be a large attendance of oil men. A new division of the Institute will be organized at the Annual Meeting to replace the present Coal and Coal Products Committee. The Iron and Steel and Institute of Metals Divisions will present extensive progams of papers assembled by sessions on topics pertinent to their respective members.

An Exhibit of Rare Metals and Minerals is being arranged for the Annual Meeting. It will be shown in the Engineering Societies Library and will consist of rare Specimens from the private collections of members of the Institute and various companies. This exhibit is being arranged by the Committee on Rare Metals and Minerals and ties in with the program of its session on Monday afternoon.

At the Annual Dinner at the Commodore the James Douglas Medal will be presented to John Van Nostrand Door and the Robert W. Hunt Medal to James Aston. William S. Unger will be the recipient of the J. E. Johnson, Jr. Award for 1930. The Class of 1880 Legion of Honor men will be welcomed. The new president will be introduced and the retiring president, Fred. W. Bradley will present his presidential address. Short speeches and plenty of time for dancing is promised.

The **Institute of Metals Division** will present an extensive program of papers starting on Tuesday afternoon, with a session on Corrosion and general subjects. Two complete sessions on Wednesday will be devoted to Copper and Brass, and at 4 p.m. Dr. S. L. Hoyt, of the General Electric Co., will deliver the Annual Lecture, his subject being "Hard Metal Carbides and Cemented Tungsten Carbide." On Thursday there will be a symposium of eight papers on Melting and Casting Metals. In the evening the Division dinner will be held at the Savoy-Plaza Hotel and G. H. Clamer, of the Ajax Metal Co., will speak on "The Induction Furnace for the Melting of Metals." Moving pictures are promised. Some of the papers are:

"Hard Metal Carbides and Cemented Tungsten Carbide," by Dr. S. L. Hoyt (Annual Institute of Metals Lecture).
"The Influence of Cyclic Stress on Corrosion," by D. J. McAdam, Jr.
"Stress-corrosion Cracking of Annealed Brass," by Alan Morris.
"Internal Stress and Season Cracking in Brass Tubes," by D. K. Crampton.
"Corrosion of Alloys Subjected to the Action of Locomotive Smoke," by F. L. Wolf.
"X-ray Notes on the Molybdenum and Iron-tungsten Systems," by E. P. Chartkoff and W. P. Sykes.
"Expansion Properties of Low-expansion Fe-Ni-Co Alloys," by Howard Scott.
"Studies in Metal Crystal Orientation—I. Determination of Orientation of Metallic Single-crystal Specimens by High-voltage X-rays," by Thomas A. Wilson.

"Etching of Brass," by Walter Graham.
"The Alpha-phase Boundary of the Ternary System Copper–silicon–manganese," by Cyril S. Smith.
"Thermal Conductivity of Copper Alloys—I. Copper Zinc Alloys," by Cyril S. Smith.
"The Alpha-beta Transformation in Brass," by Albert J. Phillips.
Certain Types of Difficulties Occurring in Copper Wire as the Result of Improper Dies and Drawing Practices," by H. C. Jennison.
"Directed Stress in Copper Crystals," by C. H. Mathewson and K. Van Horn.
"Notes on the Distribution of Lead Impurity in a Copper Refining Furnace Bath," by J. Walter Scott and L. H. DeWald.
'A Theory Concerning Gases in Refined Copper," by A. E. Wells and R. C. Dalzell.
"Comparison of Copper Bars Cast Vertically and Horizontally," by J. Walter Scott and L. H. DeWald.
"Recent Development in the Melting and Annealing of Non-ferrous Metals," by Robert M. Keeney.
"Some Notes on the Melting and Casting of Gold and Silver Alloys," by Edward A. Capillon.
"Monel Metal and Nickel Foundry Practice," by E. S. Wheeler.
"Effect of Oxidation on Certain Impurities in Bronze," by J. W. Bolton and S. A. Weigand.
"The Influence of Silicon in Foundry Red Brasses," by H. M. St. John, G. K. Eggleston and T. Rynalski.
"Melting Bearing Bronze in Open-flame Furnaces," by Ernest B. Darby.
"Oxides in Brass," by O. W. Ellis.

The **Iron and Steel Division** opens its proceedings Wednesday afternoon with a session on Ore and Foundry Practice for which are scheduled five excellent papers. A general session on Thursday morning will be devoted largely to papers on Steel, among them one on the tensile properties of steel rail at elevated temperatures. A session in the afternoon, on Alloy and Steel Melting, will be followed by the Howe Memorial Lecture, "The Future of the American Iron and Steel Industry," by Dr. Zay Jeffries, James Douglas Medallist, A. I. M. E., 1927. Some of the papers are:

"The Future of the American Iron and Steel Industry," by Dr. Zay Jeffries (Howe Memorial Lecture).
"Sintering Limonitic Iron Ores at Ironton, Minn.," by Perry G. Harrison.
"Experiment Demonstrates Method of Producing Artificial Manganese Ore," by T. L. Joseph, E. P. Barrett and C. E. Wood.
"Electrolytic Iron from Sulphide Ore," by Robert D. Pike, George H. West L. V. Steck and Ross Cummings.
"Production of Gray Iron from Steel Scrap in the Electrical Furnace," by T. F. Baily.
"Reclaiming Steel Foundry Sands," by A. H. Dierker.
"The Influence of the Rate of Cooling on the Dendritic Structure and Microstructure of Some Hypoeutectoid Steel," by Albert Saveur and C. H. Chou.
"Tensile Properties of Rail and Other Steels at Elevated Temperatures," by John R. Freeman, Jr., and G. Willard Quick.
"Endurance Properties of Steel in Steam," by T. S. Fuller.
"Large Iron Crystals: Their Production and Some of their Properties," by N. Ziegler.
"Influence of Nitrogen on Special Steels and Some Experiments on Case-hardening with Nitrogen," by Shun-Ichi Satoh.
"Progress Notes on the Iron-silicon Equilibrium Diagram," by Bradley Stoughton and Earle S. Greiner.
"Rate of Carbon Elimination and Degree of Oxidation of the Metal Bath in Basic Open-hearth Practice, II," by Alexander L. Feild.
"A New Method for Determining Iron Oxide in Liquid Steel," by C. H. Herty, Jr., J. M. Gaines, Jr., H. Freeman and M. W. Lightner.

Chuckles

According to *Scientific American*, January 1930, page 89, the main drawback of beryllium is its cost "which is now about 60 dollars a ton." Wouldn't this be interesting, if it were true?

On page 19 of the same issue of *Scientific American*, Wm. F. Sturm, speaking of the benefits to the automotive industry of information gained from racing experience at the Indianapolis Speedway, says, "Crystallization of metal used to play a certain amount of havoc with the automobile driver on the road." "Racing drivers have to have fatigue-proof metal." It does seem to us that any periodical using the term. "scientific" in its name, ought to have its imposing staff of corresponding editors censor such an article. The insertion of "so-called" before, or still better "(erroneously so-called)" after, the word "crystallization," would have avoided the necessity of our placing Mr. Sturm's articles on our Index Expurgatorius, among those of other engineers and writers who perpetuate this false phraseology.

We are indebted to F. B. Foley for a newspaper clipping which ascribes to the State Corporation Commission engineer the statement that the wreck of a train at Onley, Va., December 1st, was due to an "act of God." The clipping states that "crystallization of steel" followed by contraction due to extremely cold weather caused the rail to break.

One does not know whether to ascribe the faulty phraseology to the reporter or the engineer, but we do wish that engineers would get straightened out on this matter.

Round Table Discussions and Shop Operation Courses to Feature 1930 A. F. A. Convention

Greater interest shown by an increasing attendance at the round table meetings and shop operation courses which formed a part of the past few conventions of the American Foundrymen's Association has led the Program Committee to broaden the scope of these sessions for the 1930 annual meeting. The program for this year's convention, scheduled for the week of May 12 at Cleveland, provides for three round table luncheon meetings, covering malleable, steel and non-ferrous foundry practice.

Chairmen selected to lead these meetings are well-known leaders in their respective branches of the industry. H. M. St. John, metallurgist for the Detroit Lubricator Co., Detroit, will preside at the non-ferrous meeting; W. J. Corbett, Fort Pitt Steel Casting Co., McKeesport, Pa., will lead the steel group and P. C. De Bruyne, Moline Malleable Iron Co., St. Charles, Ill., will act as chairman for the malleable group.

No specially prepared papers will be presented at these informal luncheon meetings, but every one present will be given an opportunity to propose and to discuss any phase of management, metallurgical or shop practice he cares to bring up.

Three shop operation courses, organized expressly for the practical shop man, are scheduled. These will cover steel foundry operation, gray iron foundry operation and nonferrous foundry practice. Each course will consist of a series of three or four sessions, the leaders for each session being assigned a definite subject for discussion.

Thus, W. F. Graham of the technical division, Ohio Brass Co., Mansfield, Ohio, is in charge of organizing the course for the non-ferrous foundrymen. The subjects which will be discussed at this course include crucible, open-fire and electric furnace practice.

D. E. Broggi, foundry superintendent and metallurgist, Neptune Meter Co., Long Island City, N. Y., will lead the discussion on the indirect-arc-type furnace, and C. H. Morken, plant metallurgist, Ohio Brass Co., Mansfield Ohio, will lead the discussion on the induction-type furnace.

The steel foundry course is being organized by a committee consisting of John Howe Hall, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.; F. J. Stanley, works manager, Michigan Steel Castings Co., Detroit and C. D. Carey, works manager, American Steel Foundries, Verona, Pa. Sessions outlined for the steel course will cover chipping, grinding and riser removal; heat treating and heat-treating equipment and core practice—including anchoring, rodding, venting and sand mixtures.

Four sessions will comprise the gray iron shop operation course. The first session will cover cupola materials and will be under the direction of C. J. Scullin, Tucker-Scullin, Inc., St. Louis. Mr. Scullin will be assisted by E. J. Lowry, consulting metallurgist of Detroit.

Cupola materials and operation will be discussed at the second session, under leadership of R. S. MacPherran, chief chemist, Allis Chalmers Mfg. Co., Milwaukee. He will be assisted by F. J. Walls, metallurgist, Wilson Foundry & Machine Co., Pontiac, Mich., and by James T. MacKenzie, metallurgist, American Cast Iron Pipe Co., Birmingham, Ala.

The third session will be devoted to a discussion of gating and risering, and will be led by H. W. Dietert, foundry engineer, U. S. Radiator Corp., Detroit.

Those attending the fourth session will deal with high test irons, alloy additions and heat treatment of cast iron. Leading this session will be H. Bornstein, metallurgist, Deere & Company, Moline, Ill., who will be assisted by F. B. Coyle, research metallurgist, International Nickel Co., New York.

In addition to these round table meetings and shop operation course sessions, the usual sessions covering technical and managerial phases of the foundry industry will be held.

Arthur W. F. Green has assumed the duties of manager of the tool steel division of the Edgcomb Steel Co., Philadelphia, handling the product of the Vanadium-Alloys Steel Co. Mr. Green resigned the position of sales metallurgist with the Poldi Steel Corp. of America to take up his new endeavor.

In the future the Victor X-ray Corporation will be known as the **General Electric X-ray Corporation.** The trade-mark "Victor" heretofore used will be retained as the trade designation of the products manufactured by the General Electric X-ray Corporation.

The Flow of Metal in Molds*

With Special Reference to the Behavior of Gray Cast Iron

By George M. Enos[1]

Introduction

The production of good castings in any foundry depends upon the close control of many variable factors. The experienced foundryman recognizes the need of close correlation between all departments of the plant and progress is assured in any plant where scientific methods of control are exercised. In order to emphasize the variety of problems which may be encountered, the following outline is presented. It lists some of the points where deviation from good practice may cause the production of inferior castings.

Outline of Variables in Foundry Practice

Patterns and Core Boxes
- *Design*
  - (*a*) Shrinkage allowances.
  - (*b*) Parting surfaces.
  - (*c*) Use of fillets.
- *Materials Used*
  - Wood, metal, varnish, paints, etc.
- *Actual Construction*

The Mold and Cores
- *Materials*
  - (*a*) Molding sand.
  - (*b*) Metal molds, or metal chills.
  - (*c*) Facing materials.
  - (*d*) Other miscellaneous materials.
- *Surface in Contact with Molten Metal*
  - (*a*) Green sand.
  - (*b*) Dry sand.
  - (*c*) Metal (chills, nails, etc.)
  - (*d*) Graphite, soap stone, etc.
- *Supports in the Mold*
  - (*a*) Bars.
  - (*b*) Gaggers, chaplets, etc.

The Flow of Metal in the Mold
- *Design and Construction of Channels, Gates, Sprues and Risers*
- *Friction and Erosion*
- *Pressure*
  - (*a*) The pressure exerted by the flowing metal.
  - (*b*) The pressure exerted by the metal after the mold is filled.
  - (*c*) Pressure of gases.

The Metal or Alloy
- *Composition*
  - (*a*) Percentage variation of metals and metalloids present.
  - (*b*) Non-metallic constituents.
    1. Slag, etc.
    2. Dissolved gases.
- *Temperature*
  1. At tapping.
  2. At pouring.
- *Shrinkage and Contraction Characteristics*
  1. Actual shrinkage on cooling.
  2. Volume changes due to liberation of constituents, or to allotropic changes.

The Human Element
- *Preparation of Patterns, Cores, Mold, Etc.*
- *Assembly and Closing of Molds*
- *Handling of Metal*
  - (*a*) Melting.
  - (*b*) Pouring.
  - (*c*) Shaking out the castings.

The preceding outline, while admittedly incomplete, is general enough to apply to any foundry. The making of a casting starts with the designer, who furnishes to the pattern shop a plan for a certain job. The pattern maker may err in his judgment of materials or in manipulation, and if so, the difficulties the foundry proper encounters in making a good casting are increased. In making the cores and molds the choice and treatment of core sands and molding sands present numerous difficulties.

The problems of support in a mold against the pressures which will be developed are numerous and complex, and are usually solved by "cut and try" methods, based on previous experience. The surfaces which are to be in contact with the molten metal will depend on the finish and amount of chilling desired.

The problem of the proper placing of gates, sprues and risers is also usually solved by trial methods on any particular job. The composition of the metal may be arranged in advance by proper mixing and melting of the raw materials, but the structural constituents which will be present depends, in many alloys, on the rate of cooling of the casting in the mold.

Throughout the whole plant there is the "human element." It is necessary to rely upon the judgment and skill of the workmen, that the desired results may be obtained. In this and later articles it will be assumed that the mechanical work in connection with the making of castings has been correctly performed, in order to eliminate one variable from consideration.

While many of the principles, and some of the practice, which will be discussed in this and succeeding articles are applicable in any foundry, the discussion will be concerned primarily with the manufacture of gray iron castings.

Problems of Pressure and Support in Molds and Cores

Molding sand possesses strength through cohesion, the actual strength depending on its moisture content and other conditions. In some cases the sand, whether in molds or cores, must have additional support. Molding sand, and cores in place in a mold, must withstand the following forces:

(*a*) Pressure from gases as the iron is poured.
(*b*) The actual pressure of the molten metal.
(*c*) The wear or abrasion of the running metal.
(*d*) Gravity. In the cope the sand must support its own weight.

(*a*) **The pressure due to gases** will usually be released through the natural channels in the sand and through the risers and vents. The steam generated will, of course, cause pressure to develop, and the amount will depend upon the temperature of the steam. On changing from liquid water to steam, at constant temperature (boiling point), one pound of water would be expanded from 0.016 cu. ft. to 26.79 cu. ft., pressure constant. If confined, it is obvious that the pressure must increase, unless the temperature is very rapidly reduced to offset such a change. Confinement of gas or steam to the extent of causing a "blow" is not uncommon if the sand is improperly vented.

(*b*) **The actual pressure of the molten metal.** It is difficult to obtain accurate figures as to the actual pressure developed. By analogy with hydrostatics and hydraulics we can picture, and to a certain extent calculate, the pressures developed.

Cast iron in a mold behaves as any liquid would do with respect to development of pressures. It should be remembered that molten (liquid) iron does not behave as water would if poured in a sand mold, since the iron will not "wet" the sand. A sand mold which is porous with respect to gases and

* Part I of an article to be published in two parts. Part II will appear in the March issue.

[1] Assistant Professor of Metallurgy, University of Cincinnati.

liquid water (both are fluids) is impervious to liquid metal, which is, of course, also a fluid. While there may be a limited solubility of oxides in molten iron, the sand and iron do not react chemically nor dissolve each other to any appreciable extent. If any loose sand is encountered by the iron, it simply floats on the surface of the iron due to the difference in specific gravity.

It can be considered, then, that the iron as poured will be in an impermeable container and will obey the general physical laws applying to liquids. The principles may be found in any standard reference book on physics, but for convenience are briefly stated below:

Pressure is a general term applied to denote the ratio between the force applied to any surface and the area of that surface, i. e.

$$P = \frac{F}{A}$$

where P = pressure
F = force
A = area

The pressure may be expressed in various units. In engineering work they are frequently expressed in "pounds per square inch" or in "pounds per square foot."

I. The pressure across any surface drawn in a liquid at rest is normal to that surface.

II. At any point in a liquid at rest the pressure is the same in all directions.

III. The pressure at any point in a liquid at rest under the force of gravity is directly proportional to the depth.

IV. Other things remaining the same, the pressure at any given point in a liquid varies directly as the density of the liquid.

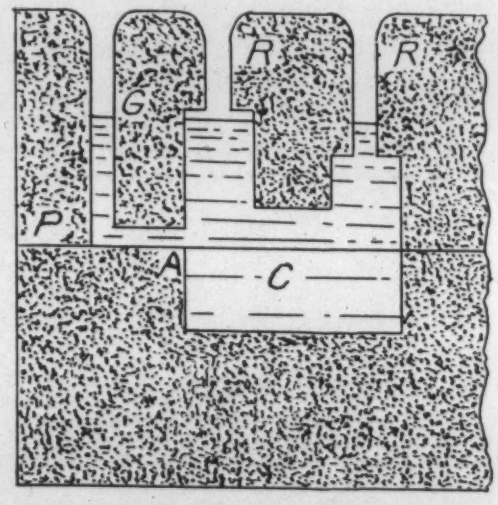


Fig. 1—Schematic Drawing Showing Cross-Section Through a Mold, for a Casting of Irregular Section; the Mold Is Partially Filled

It is the depth of the liquid and not the volume which must be considered in computing pressures, assuming that we are considering a liquid at rest, i. e., after a mold is filled but the iron not yet solidified. In connecting channels the liquid will rise to the same height regardless of the design of the channel. See Fig. 1. The gates and risers in a casting, will all be filled to an equal height, as long as they are connected and the iron remains fluid.

At any point in the liquid, the total pressure will be the total weight of the liquid supported by any small area, divided by the area, plus the pressure of the air upon the free surface of the liquid. Then, the difference in pressure, $P_2 - P_1$ between any two points depends only upon their difference in level, $h_2 - h_1$, and

$$P_2 - P_1 = D\,(h_2 - h_1)$$

where D = density of liquid
h_2 and h_2 = vertical distance
P_1 and P_2 = pressures.

It may be further noted that the pressures are independent of the form of the containing vessel.

The density of liquid iron is reported as 6.88. Gray cast iron, solid, has a density of 7.85, although this value may vary with composition.

One foot of liquid water at normal temperature exerts a pressure of 62.4 lbs. or 0.433 lbs./in.^{2} If the value for the density of liquid iron is taken as 6.88, then $6.88 \times 0.433 = 2.97$, or the pressure exerted on one sq. in. by one foot of iron, or approximately 0.25 lbs./in.^{2} per inch of iron. In the handbooks this value is usually given as 0.26 for cast iron. Since the actual density of liquid cast iron will vary with composition, this discrepancy of values is not surprising.

If the iron is at rest, the pressure exerted by the liquid iron is readily computed. We can assume that in a mold the walls of the mold will withstand the lateral pressure. However, the cope may be lifted by the iron unless it is secured, or is held down by a weight. The weight necessary to withstand the lifting force of the iron may be computed as follows. Find the area of the casting at the joint of the flask, that is, the area which will be exposed to the upward thrust of the iron. Multiply this area by the height of the pouring head, that is, the vertical distance from the joint to the pouring basin, and multiply this value by 0.25. If the measurements are made in inches the answer will be in pounds.

So far the pressures due to liquid iron at rest, or "static" pressures have been considered. Actually the moving iron exerts a pressure also and this may be expressed by:

$$P = {}^1/_2\, mv^2 \text{ (the kinetic energy)}$$

where P = pressure
m = the weight of the moving iron
v = the velocity.

See Fig. 2, and footnote.* (Torricelli's and Bernoulli's Theorems.) Usually we will not have sufficient data as to the velocity to make any use of these formulae. The flow of the metal in a mold is retarded by friction as it comes in contact with the sand. The coefficient of friction will depend on the nature of the facing material. In general, we know that the flow of the metal is retarded, due to friction, in proportion to the surface area of the channels through which it flows. Thus four 2.5 inch diameter gates give a cross-sectional area equal to one 5 inch diameter gate, but the resistance to flow (head pressure being the same) is double in the four gates to that of the single gate, because the combined circumferences of the four 2.5 inch gates are equal to 31.4 inches, while the circumference of the single five inch gate is 15.7 inches. Varying the size of the gates and risers and sprues affects the rate of flow, but it is impractical to attempt to predict the exact effects by computation methods. To lessen the shock when the rising iron hits the cope, and thus minimize the pressure due to the iron in motion, it is common practice to lessen the pouring rate when the mold is partly filled.

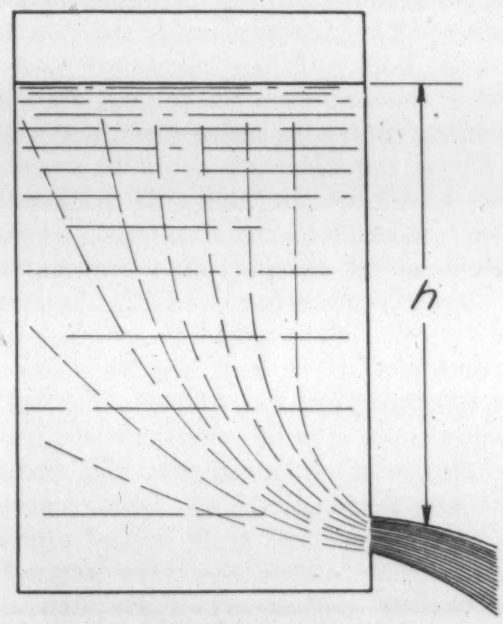


Fig. 2—A Diagram Illustrating Torricelli's & Bernoulli's Theorems

Because it is necessary to weight or tie down large castings, it is assumed by some that to insure "dense metal" it is necessary to have a gate or casting head of considerable height and thickness. Metals, like gases, may be made more dense by pressure, but it requires pressures of many tons per square inch to produce marked effects. In this connection a pressure of six or seven tons per square inch is negligible. The effect of variation of height and section of gates and risers on the "grain" of the iron is due to other factors.

* Neglecting friction, Torricelli's theorem may be stated as $^1/_2\, MV^2 = m\,g\,h$, or $V = 2gh$, where V = speed of liquid passing orifice during any small interval of time, M = mass of liquid leaving during this time interval and g = acceleration due to gravity. Considering flow of iron in a mold, since h will be maintained approximately constant during pouring, it can be readily seen that the velocity will be constant until the mold is nearly full unless the orifice be increased by wear of the flowing metal. The velocity will, of course, be decreased in the main cavity of the mold since it will be larger in cross section.

The stream lines shown refer more particularly to Bernoulli's theorem, each stream line being considered as a "tube of flow," where friction does not occur. The theorem may be stated, for any tube of flow, as:

$$P + g\rho h + {}^1/_2\, \rho v^2 = \text{a constant}$$

P = hydrostatic pressure. g = acceleration due to gravity. v = velocity. ρ = density of the liquid. h = distance above the horizontal plane used as a reference.

The molten metal in the gates and risers is in fluid contact with that of the interior of the casting during the process of solidification, thus supplying metal to fill up spaces left vacant by the shrinkage which accompanies the change of state from liquid to solid. If, because of too thin a channel, this feeding of molten metal cannot take place, shrinkage defects are bound to occur. A second effect which may possibly influence the quality of the casting is that a moderate pressure on the molten metal acts to hold dissolved gases, just as in soda water a moderate pressure keeps the carbon dioxide dissolved until the pressure is released. Blow holes are formed in metal which is solidifying, not in the solid metal. Denser structure results from the absence of blow holes. It should aid in the prevention of blow holes to have sufficient fluid head, with the mold well tied or weighted down.

(*c*) **The flowing metal** exerts an abrasive action on the walls of the mold and on the walls of the connecting channels. To minimize this wear, the parts of the mold which will receive the greatest wear may be "nailed" or otherwise protected. In Fig. 1, the iron flowing over the shoulder marked "A" would be likely to loosen the sand, if the shoulder is not protected. Sand loosened by flow of metal in this way, or by actual erosion on the sides and bottom of the mold or channels should normally find its way to the top of the metal, that is, to the highest point. The highest points in the molten metal are the gates, and risers. (When risers are used.) It is unreasonable to expect the sand or dirt to rise against the metal as long as the pouring continues, hence dirt should be carried out in the risers. If the risers are not used, or are improperly placed, the "dirt" or sand may be pocketed at some point in the upper part of the mold cavity, and be held there by the solidifying metal, causing rough or irregular metal surface, if not a more serious defect. In Fig. 1, several sharp corners are shown. These would be avoided in practice, for reasons mentioned above, and also because of casting strains which would be set up.

To introduce the molten iron into the cavity where the casting proper is to solidify, without introducing slag from the pouring ladle and without carrying in sand or dirt caused by erosion in the gates or sprues, is often an important problem. It may be impractical to depend on the risers carrying out the dirt, or perhaps risers are not needed for the purpose of controlling the shrinkage during solidification, and hence can be omitted if no loose dirt is introduced into the "pattern" cavity. Numerous designs of gates have been tried. Five types of gates are shown in Fig. 3, each of which has advantages for a certain type of work. Certain auxiliary devices are sometimes employed such as special pouring basins, usually made up in the same manner as a core is made, or "strainer" type cores, or metal strainers mounted above a "pouring" basin. (See Fig. 3). The metal strainers retard the flow of the metal until the strainer melts, thus allowing the pouring basin, located beneath, to fill and float any loose dirt to the top. The metal from the pouring basin can then decant into a gate leading to the mold proper.

(*d*) **In the cope** "gaggers" or "soldiers" are used in the larger molds to help support the sand and hold it in place, thus avoiding "fall-outs." The correct placing of these supports is a matter of experience and judgment. Copes may have additional support for the sand in the form of bars, and the shape and design of these bars is an important item in the designing of flasks.

Cores may require support in the mold. They may be supported and anchored in place by chaplets, wires, or bolts, as may be required, in order to avoid dislocation before pouring, and to resist the thrust of the molten iron during pouring. In the construction of cores, arbors, wires and the like, may be needed to maintain rigidity and help hold the sand in place.

The placing of proper supports in molds and cores is largely a matter of experience. The supports used, must, of course, be such that they will burn or fuse if they are to be brought into direct contact with the iron, but must be rigid and permanent enough to stay in place as long as needed. Gaggers may in time "lose their life" but in general they do not come in direct contact with the iron, and hence can be used over again. Giving them a clay wash prior to use may help to protect against the high temperatures.

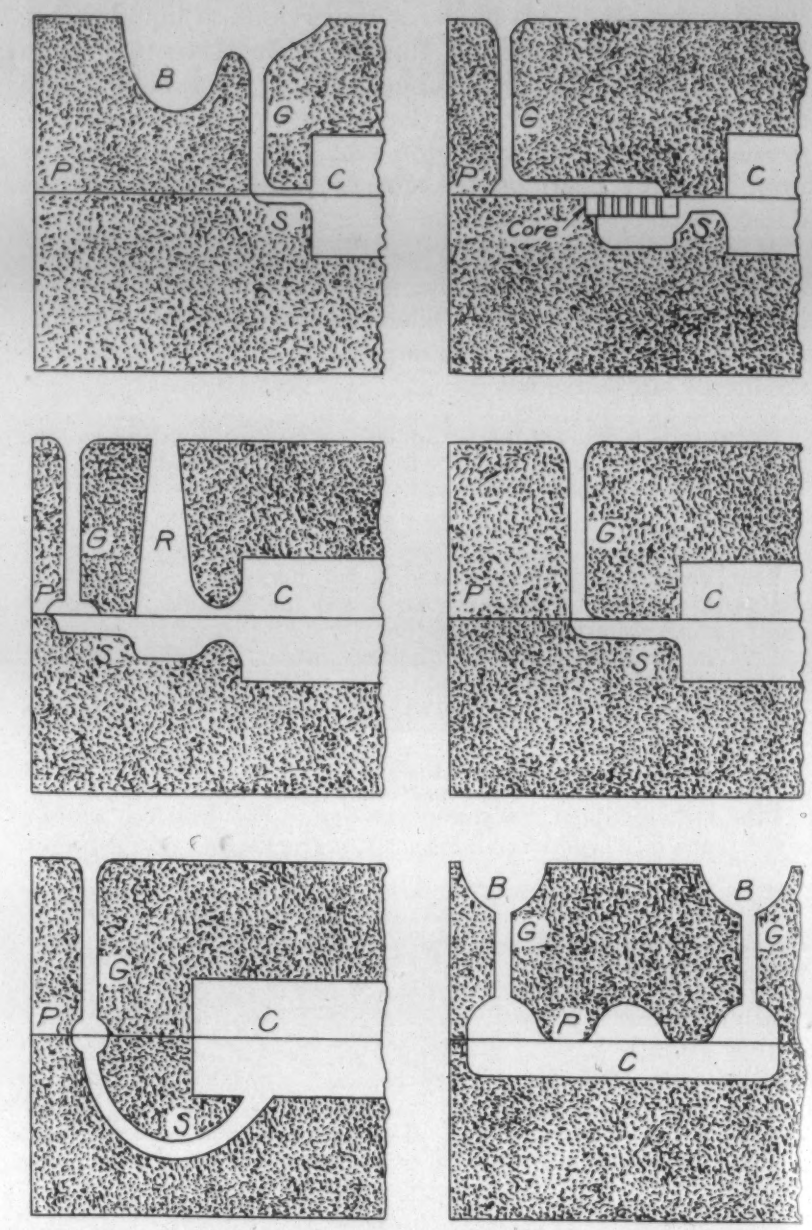


Fig. 3—Schematic Drawings of Sections Through Molds Illustrating Several Types of Gates

In each drawing G refers to the down-gate, and C to the pattern cavity. P indicates the parting line, and S refers to a cross-gate or "sprue." (a) Simple pouring basin with direct gate to casting. (b) Gating through a "strainer" core. (c) Gating through a riser. This type of gating is useful in solving shrinkage problems encountered in certain types of castings. The riser is not filled until the casting cavity is filled. The sprue between the down gate and riser is of such size that it will solidify before the connecting channel from riser to casting. (d) Simple type of gate with no precautions taken to insure clean iron. (e) Horn gate, for bottom pouring. If the small end of the horn were at the casting cavity a nozzle effect would be developed and the iron would enter the mold with considerable velocity. The wide end entering the cavity allows a decrease in velocity to occur, thus "easing the iron into the cavity." (f) "Pop-gate" B and B are cross-sections through an annular pouring basin. Only two down gates are shown, but more may be used as needed.

In all drawings in Fig. 3, the flasks supporting the sand are not shown, and the pattern cavity is obviously conventional; no cores or other details are shown. Many variations and combinations of the designs shown are used in practice. The drawings are not made to scale, and are intended only to illustrate principles.

Reprints of Professor Clark's article, "X-ray Metallography in 1929" which appeared in five numbers, July to November 1929, inclusive, can be obtained at one dollar a copy. The supply is limited. Many readers have written us that the article has aroused a new interest with regard to X-ray Metallography. Address your order to METALS & ALLOYS, 419 Fourth Ave., New York.

National Steel Rebuilding Furnace

National Steel Corporation has closed down its furnace at the Weirton Steel Company plant at Weirton, W. Va. for reconstruction. The new furnace, which will be completed and in operation early in April, will have a capacity of more than 1,100 tons and will be the largest in the world.

Magnesium and Its Alloys in Aircraft[1]

By H. G. Harvey[2]

Aircraft construction has always been based on the employment of materials having the best combination of lightness and strength. Wood and fabric have been popular for many years and fulfill the major requirements mentioned, but the added need of durability and ruggedness is gradually forcing this industry toward an increasing use of metals. Fortunately, progress along metallurgical lines has kept step with aircraft requirements, and the high-strength aluminum alloys in wrought forms and in castings have enabled airplane manufacturers to meet the ever-increasing demand for durability, strength and lightness.

The efficiency of an airplane, at least from a commercial viewpoint, is measured by its pay load or the useful weight which it can lift and transport. The desire for lightness is, therefore, as keen as ever. Electrochemistry is helping to meet this requirement by the successful production of magnesium, with its one-third lighter unit weight as compared with aluminum.

It has taken approximately twenty years to develop the magnesium industry, and bring the cost of its products to a point where they are of commercial importance. The slow development of this metal has been due not entirely to the high original cost, but rather to its inherent chemical and mechanical characteristics, and the difficulties involved in working it into useful shapes. It is only in the last few years that these obstacles have been overcome through the discovery of methods of purification, the technique of rolling, casting and forging and the adoption of binary and more complex alloys with greatly improved physical properties and increased corrosion resistance, with negligible change in weight.

A number of these ultra-light magnesium alloys are susceptible to heat treatment, and in the form of castings possess mechanical properties substantially equal to the best of the high-strength cast aluminum alloys, so widely used in aircraft and aircraft engine construction. Pure magnesium has a specific gravity of 1.75, and is, therefore, the lightest of all metals that are stable under atmospheric conditions. The mechanical strength, as is the case with most pure metals, is not high, and consequently the pure metal finds its only applications where lightness is most important and strength not an essential factor.

[1] A paper presented at the Fifty-sixth General Meeting of the American Electrochemical Society, Pittsburgh, Pa., September 1929.

[2] Aluminum Co. of America, Cleveland, Ohio.

Physical Properties of Magnesium Alloys

Magnesium alloys with practically all the common metals, with the exception of iron and chromium. A large field has now been explored by investigators in search of alloys interesting from a structural standpoint, and many valuable facts have been discovered concerning the solubility of the common metals in magnesium, the occurrence of metallic compounds, and the strength and resistance to corrosion of many alloy combinations.

Reference must be made to the valuable contributions of Gann and Winston[3] and Gann[4] on this subject. This alloy research has led to the conclusion that aluminum, manganese and zinc are the best elements for alloying with magnesium to produce the desired combination of light weight, high mechanical strength and resistance to corrosion. Copper and cadmium in small amounts add special characteristics.

Magnesium alloys are available in commercial forms such as sand castings, forgings, extruded shapes and rolled sheet, and some variation in the alloy composition is necessary to bring out the best characteristics in these finished products. Moreover, the actual fabricating operations often necessitate certain physical characteristics, which can be obtained only through a careful selection of the alloy. For instance, forging and rolling operations require high elongation in the original cast billet, while an alloy to be adaptable to successful sand casting must have, in addition to good "as cast" properties, a high degree of fluidity and a freedom from hot shortness.

All of the above considerations are problems for the manufacturer rather than for the user, but they are mentioned to indicate that the industry has now progressed to the point where these problems have been solved, and the aircraft and engine builder need only examine the physical property tables, or, better yet, the products themselves, to be convinced of the accuracy of this statement.

Magnesium alloy products are produced in this country by the American Magnesium Corporation[5] and the Dow Chemical Company, and in Germany under the trade name of "Electron." The physical characteristics of the products from these three sources of supply are sufficiently alike to al-

[3] J. A. Gann and A. W. Winston, "Magnesium and Its Alloys," *Ind. Eng. Chem.*, **19**, 1193 (1927).

[4] J. A. Gann, "Treatment and Structure of Magnesium Alloys," Preprint, *Amer. Inst. of Min. & Met. Eng.*, October 1928.

[5] Sales Agents, Aluminum Company of America.

Table I—Mechanical Properties of Magnesium Alloys

			Rolled Products			Forgings	
	Sand Castings	Extruded Products	Cold Rolled 14 Ga. or under	Annealed 14 Ga. or under	Hot Rolled Plate	Light	Heavy
Specific gravity	1.80	1.80	1.77	1.77	1.77	1.78	1.78
Tensile strength:							
Lb. per sq. in.	26,000–38,000	42,000–45,000	40,000–45,000	37,000–38,000	35,000–36,000	39,000–42,000	35,000–37,000
Kg. per sq. mm.	18.3–26.7	29.5–31.6	28.1–31.6	26.0–26.7	24.6–25.3	27.4–29.5	24.6–26.0
Yield point:*							
Lb. per sq. in.	8,000–11,000	22,000–26,000	20,000–27,000	20,000–22,000	15,000–20,000	22,000–24,000	20,000–24,000
Kg. per sq. mm.	5.6–7.7	15.5–18.3	14.1–19.0	14.1–15.5	10.5–14.1	15.5–16.9	14.1–16.9
Percent elongation in 2 in. (51 mm.)	8–15	11–16	5–10	18–24	10–14	6–15	8–14
Percent reduction in area	9–16	13–20	.....	.....	10–15	8–20	10–20
Young's modulus:							
Lb. per sq. in.	6.6×10^6	6.6×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Kg. per sq. mm.	4640	4640	4570	4570	4570	4570	4570
Compressive strength:							
Lb. per sq. in.	40,000–50,000	60,000	.....	.....	.....	43,000–55,000	40,000–52,000
Kg. per sq. mm.	28.1–35.2	42.2	.....	.....	.....	30.2–38.7	28.1–36.6
Endurance limit:†							
Lb. per sq. in.	8,500–10,000	.....	.....	.....	.....	.....	.....
Kg. per sq. mm.	6.0–7.0	.....	.....	.....	.....	.....	.....
Impact (Dow):							
Foot-pounds	3.3–6.1	.....	.....	.....	.....	11.2–12.5	11.2–12.5
Kg. m.	0.46–0.84	.....	.....	.....	.....	1.5–1.7	1.5–1.7
Brinell hardness	44–58	56–62	60–64	51–53	50–55	50–60	50–55
Scleroscope hardness	25–31	29–37	37–39	31–33	31–36	31–37	31–36

* Considered as the load at 0.1 percent elongation. † Rotating beam 500,000,000 cycles.

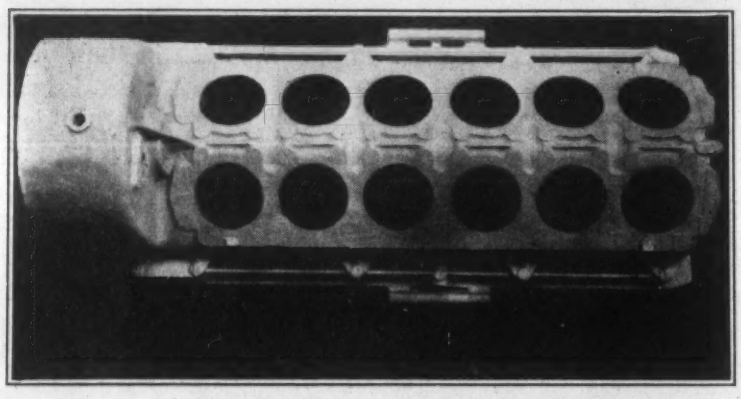
low the writer for the purpose of this paper to tabulate the general properties which can be expected from magnesium alloy castings, forgings and other forms useful in the aircraft industry. Published contributions have been freely drawn upon for data, and have been used in constructing Table I.

In examining the data of Table I, it must be understood that the range of figures given for the physical properties of any particular product, for instance sand castings, is intended to be sufficiently broad to cover maximum and minimum values for a number of casting alloys. In order to be more specific, let us consider a single typical casting alloy. This is called No. AM 7.4, and castings of it are susceptible to heat treatment. The composition is: magnesium, 92.6 percent; aluminum, 7.0 percent; manganese, 0.4 percent. The properties "as cast" and "heat treated" are given in Table II.

Table II—Sand Castings of AM7.4 Alloy

Average Properties	As Cast	Heat Treated
Tensile strength, lb. per sq. in.	25,000	33,000
Tensile strength, kg. per sq. mm.	17.6	23.2
Yield point,* lb. per sq. in.	8,500	9,500
Yield point, kg. per sq. mm.	6.0	6.7
Elongation in 2 inches (51 mm.), percent	6	10
Reduction in area, percent	7	12
Endurance limit (rotating beam), lb. per sq. in.	8,500	10,000
Endurance limit (rotating beam), kg. per sq. mm.	6.0	7.0
Brinell hardness	50	51
Scleroscope hardness	31	31
Specific gravity	1.785	1.785

* Yield point is taken as stress at point on stress-strain diagram which deviates 0.1 percent from modulus line.



Bottom View of Crankcase Casting; Weight, 40 lbs. Curtiss Aeroplane and Motor Co.

The suitability of heat-treated castings for aircraft use is fairly evident when one considers the average tensile strength of 33,000 pounds per square inch (23.2 kg. per sq. mm.) with 10 percent elongation in two inches (51 mm.) in a casting weighing only two-thirds that of an equivalent aluminum casting. The effect of the lower specific gravity is better indicated by calculating the strength-mass ratio or tensile strength in pounds per square inch divided by the specific gravity.

Table III—Comparison of Strength-Mass Ratio of Magnesium and Aluminum Alloys

Alloy	Minimum Tensile Strength	Specific Gravity	Strength-Mass Ratio
AM 7.4 H. T. magnesium alloy, cast, lb. per sq. in.	29,000	1.79	16,200
AM 7.4 H. T. magnesium alloy, kg. per mm..	20.4		11.4
195 H. T. aluminum alloy, cast, lb. per sq. in.	29,000	2.77	10,470
195 H. T. aluminum alloy, cast, kg. per sq. mm.	20.4		7.4
12 aluminum alloy, cast, lb. per sq. in.	18,000	2.83	6,360
12 aluminum alloy, cast, kg. per sq. mm.	12.7		4.5

These ratios are given in Table III for AM7.4 H. T.[6] magnesium castings, and for the well-known No. 195 and No. 12 aluminum casting alloys, using minimum tensile values in all cases. This ratio is a valuable guide in determining the suitability of a metal for a particular purpose, and it should be especially considered by aircraft manufacturers to whom lightness with strength is of great importance.

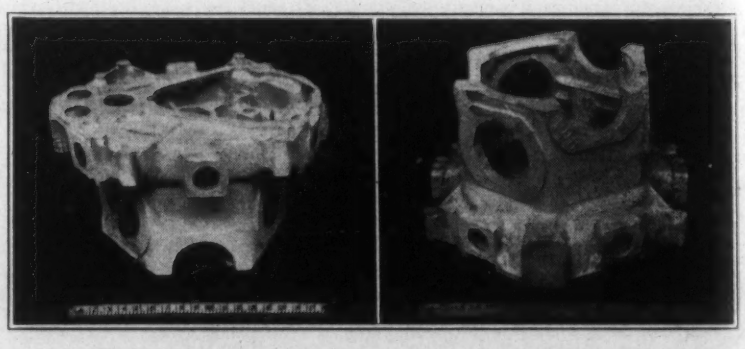
[6] H. T. indicates the heat-treated alloy

Resistance to Corrosion

In the case of aircraft, of greater importance than high mechanical strength, is the question of the durability of the materials entering into engine and airplane construction. The lack of stability of magnesium in salt water, and even to some extent in fresh water, was a characteristic of the product made some years ago. Metal of inferior quality has been distributed and alloys used in fabricated products which had satisfactory physical properties, but no attention was paid to corrosion resistance. The corrosion of these alloys has produced an erroneous impression of the stability of pure magnesium, or of the good alloy compositions.

This subject has been given careful consideration in recent years, and has led to the development of particular alloys and compositions with not only high mechanical strength, but also much improved corrosion resistance. One of the first steps by which the present satisfactory stability is secured is through careful purification, and secondly, by the addition of certain constituents which will increase the stability. Manganese is a good example of such a constituent, and it is now added to most of the commercially used alloys. Specimens of this type of alloy have been subjected to weather exposure for approximately a year, with results comparable to those obtained with the commonly used aluminum-base alloys. This subject has been fully discussed by J. A. Boyer.[7]

Although the stability of modern magnesium alloys is now good, there will be many cases where protective coatings should be used. A number of these offer good adhesion to the magnesium surface and substantial protection. The best of these appear to be electrodeposited rubber; thermoprene resin paint made with one pound of aluminum powder per gallon; or, aluminum paint made with spar varnish mixed with two pounds of aluminum powder per gallon. Aluminum paint made with a hard-drying spar varnish makes a good top coat. Even after two and a half years' exposure, these coatings were in good condition, and the magnesium alloy specimens still retained practically their original physical properties.



Bottom View Top View

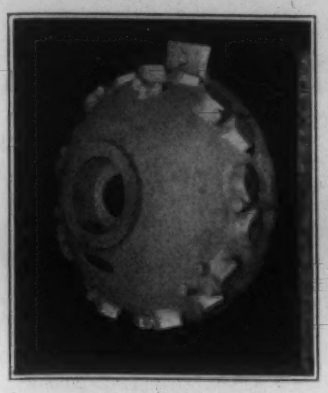
Crankcase Casting (Radial); Weight, 38 lbs. Curtiss Aeroplane and Motor Co.

Castings and Forgings

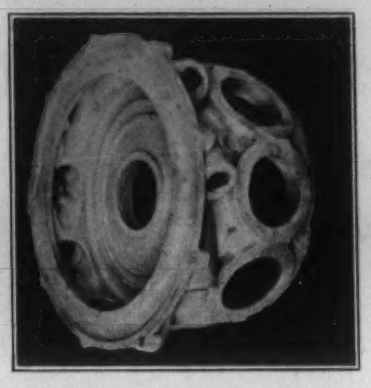
Unquestionably, the most useful magnesium products for aircraft construction are magnesium castings, for these offer an opportunity for a substantial reduction in weight. Foundry practice has been constantly improved and simplified to the point where it is safe to say that, within reason, almost any casting which can be made in aluminum can be cast in magnesium. Castings weighing well over one hundred pounds have been poured and certainly the end, so far as size is concerned, has not yet been reached.

Magnesium at an elevated temperature will react with water, and to some extent with silica, and it has been necessary to develop special sand mixtures and methods of molding to cast the metal successfully. Several photographs of sand-cast aircraft parts are reproduced in this paper to illustrate typical applications. Casting in permanent molds has not

[7] J. A. Boyer, "The Corrosion of the Magnesium and Magnesium-Aluminum Alloys Containing Manganese," Report No. 248, National Advisory Committee fo Aeronautics.



Front End (thrust) Crankcase, 9 Cylinder. Weight, 15 lbs. Lycoming Mfg. Co.



Crankcase, 9 Cylinder. Weight, 33 lbs. Lycoming Mfg. Co.

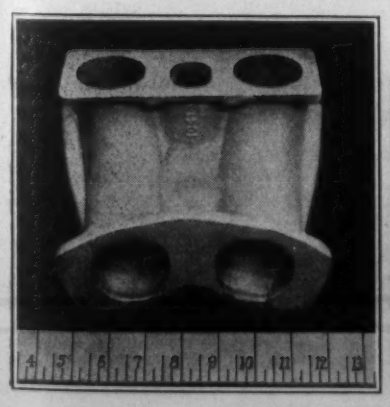
as yet been worked out commercially, but the experimental results indicate a successful outcome in the near future.

Magnesium alloy forgings are another product which will be interesting and useful to aircraft manufacturers. While the casting of magnesium can be considered as definitely commercial, with only the refinements and lower costs to follow with increased production, the making of magnesium forgings has just emerged from the experimental stage. Aircraft propellers, supercharger impellers, pistons and a number of engine parts have already been made in sufficient quantity to prove the value of this product and to determine the physical properties with accuracy. Figures on these are given in Table I. A number of forged magnesium propeller blades, recently supplied to Wright Field, showed the following properties:

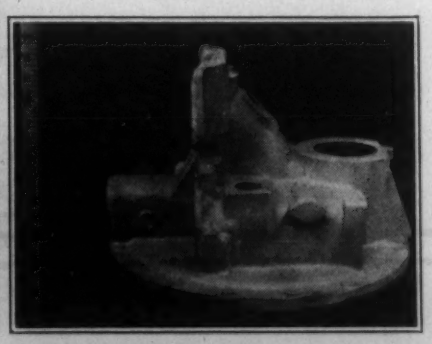
Alloy AM 4.4	lb. per sq. in.	kg. per sq. mm.
Tensile strength	34,000	23.9
Yield point	22,000	15.5
Elongation in 2 inches (50.8 mm.), percent	6	..

Forging dies designed for the working of aluminum alloys can, in general, be used for the forging of magnesium alloys. The latter harden up much faster than an aluminum alloy with the same amount of mechanical working, and require a forging technique differing somewhat from standard aluminum forging practice. For best results in the final product, careful selection of stock and preliminary treatment are necessary. Magnesium forgings will no doubt find increasing uses, because of their higher mechanical strength and the economies possible in machining and finishing operations.

The magnesium supercharger impeller is a good example of an ideal application, for in this case the lighter metal, even when revolving at high speeds, produces lower centrifugal stresses. Forged magnesium propeller blades can be produced with weights not differing materially from those obtained with wood, and will surely find a field in aircraft, especially in the large sizes and for use with geared engines.



Carburetor Spacer. Weight, 3 lbs. Curtiss Aero & Motor Company



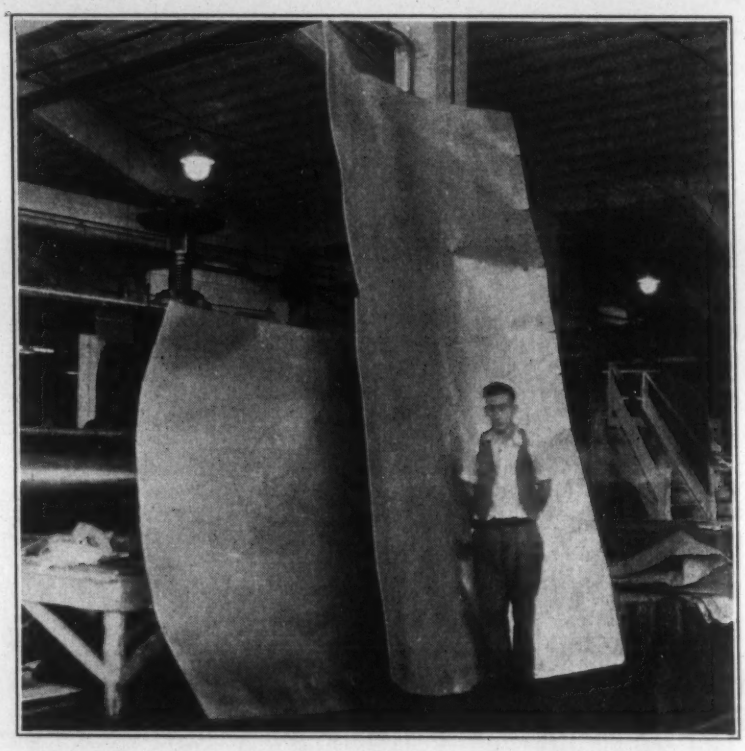
Rear End Crankcase Casting (Radial). Weight, 28 lbs. (12.7 Kg.). Pratt & Whitney Aircraft Corp.

Magnesium Sheet

Magnesium sheet can be obtained in any gage down to 32 B and S. It is hot rolled from cast billets, and finished by cold rolling in much the same manner as aluminum. The physical properties of the product in the alloy form have been given in Table I. Widths up to 70 in. (178 cm.) and lengths up to 120 in. (305 cm.) are commercially produced. The corrosion resistance of rolled sheet is not as high as in the case of castings. It can, however, be considered stable for all ordinary atmospheric conditions. For use around salt air, some suitable protection is necessary.

Magnesium sheet does not lend itself well to cold forming, because of the rapid hardening characteristic of magnesium. If a change in shape is required, as would be the case in the construction of low-drag cowling, the spinning operation would either have to be carried on with metal at a temperature of approximately 275° C., or by resorting to frequent annealing operations, if the deformation is made at ordinary temperatures.

For the linings on aircraft or pilot boats, magnesium sheet can be easily applied without wrinkling and with smooth, tight seams, using duralumin rivets. Constant progress is being made in the production of sheet with still higher mechanical properties and as increasing production permits, at lower manufacturing costs.



Magnesium Sheet (rolled). Size as Illustrated 0.065″ × 75″ × 120″. Will Finish to 0.065″ × 72″ × 118″

Conclusion

Because of their high strength and light weight, magnesium castings, forgings and extruded shapes are already finding many uses in aircraft. Engines, of course, present many obvious applications, and a number of such parts are illustrated. It will be unnecessary to specify such parts by name, for the list would comprise practically every piece from a crankcase to the smallest cover plate. Engine starter bodies have, for several years, been made with magnesium castings. Forgings find use where the number of pieces justifies the tool or die expense. Forged propellers and supercharger impellers have already been mentioned.

Magnesium pistons offer many advantages, especially when used in engines with high compression ratios. However, there are still a number of characteristics which must be improved if the magnesium piston is to behave well in an aircraft engine. Research, however, seems well on its way toward solving these requirements, and magnesium pistons with their great advantage of lightness will no doubt play an important part in aircraft engine design.

Magnesium is not a new metal in point of time, but commercially it is a comparatively new metal. Its commercial development has lagged for many years, awaiting an industry which would require its special properties. Aircraft construction demands the lightest materials, and it may be predicted that magnesium will play an important part in the commercial development of the airplane.

Automatic Temperature Control

Chromium Plating Solutions

By R. W. Saunders[1]

When chromium plating first entered the field as a production process, the wide variety in equipment, particularly in tank construction, and the lack of any accepted standard complicated the adaptation of temperature control. Each application had to be considered as a specific case and frequently the arrangement was such that satisfactory temperature control was impossible. It is now possible to classify the several arrangements into two general groups: those which are adapted to automatic control, and those which should be avoided.

It is now an accepted fact that satisfactory results in chromium plating, for resistance to tarnish and wear, as well as for beauty of appearance, depend entirely upon a proper balance between the variables controlling the process. These variables are:

1. Solution composition.
2. Current density.
3. Temperature.

Any one of the practical solution compositions has very definite current density and temperature factors. These factors are interdependent. A low current density at a high solution temperature will produce brownish colored oxide in the deposit. A higher current density, at a lower solution temperature, will produce gassing due to evolution of hydrogen and the deposit will be bright. A still higher density, at the same temperature, will increase the plating or current efficiency, but the deposit becomes gray and dull. Thus, for any given solution composition and current density there is only one temperature at which bright plating can be done at the maximum efficiency.

Solution composition depreciates very slowly and in proportion to the deposition of metallic chromium on the work. Current density is constant when once established.

The temperature of the solution increases rapidly when work is in process, due to the resistance of the solution. When there is no work in the bath, the circulation due to gassing stops and the solution becomes stratified as to temperature. The working portion of the solution soon exceeds the critical temperature and rejection begins.

For bright plating at a maximum efficiency, with any given solution composition and current density, the determining factor is temperature, and the control of the temperature factor has placed Chromium Plating in the field of a production process. Automatic control is a necessity and has become an accepted practice.

Type of Control Necessary

At the inception of control on chromium plating equipment, opinion was about evenly divided regarding single control of heating and duplex control of heating and cooling. It was discovered in most cases that, after the plating bath was up to the required temperature, the operation of plating caused an over-run of temperature with the result that material was frequently rejected. Experience gradually convinced the majority that duplex control was superior and in most cases necessary.

When a tank is operated at its rated capacity, the heat is shut off by the controller after the solution reaches the desired temperature, and thereafter the cooling medium only is used. Due to the inherent tendency of all practical chromium plating solutions to heat up during the process of plating, we hesitate to recommend a single heating control in any case.

[1] Engineering Development Department, The Brown Instrument Company, Philadelphia, Pa.

Types of Chromium Plating Tanks

There were many different types of tanks when equipments were first installed; plain steel glass lined, plain steel with plate glass inserted along the sides and ends, lead lined steel, etc. Some had jackets for heating or cooling, or both; others had water jackets gas heated, and still others had coils arranged in different ways for either heating or cooling.

Types Not Adapted to Control

In the early tank specifications, there was a tendency to disregard the fundamental requisites for proper temperature control. Many designs failed to provide for even and rapid distribution of heating and cooling.

Type A—In some instances, a jacketed tank was installed with gas burners underneath for heating. This type is undoubtedly the worst from every point of view and should not be considered for application of temperature control under any circumstances.

Type B—A tank having a single coil on the bottom has the following three very undesirable features and should be avoided.

1. The coil will heat the solution but will not cool it.
2. Work dropped into the tank will catch in the coil which may retard removal to the extent of spoiling the work.
3. Sludge covers the coil and soon impairs its one virtue of heating.

Type C—A steel jacketed tank, having water within the jacket, is heated by letting live steam into this water or by steam coils installed within the jacket and cooled by circulation of cold water.

It is possible to control this third type if the water in the jacket and the plating solution are in constant circulation. The water should be circulated through an external heating and cooling unit. However, even this arrangement should be resorted to only if redesign is impossible.

Types Subject to Control

As an outcome of the earlier types of equipment, we find the leading chromium plating engineers and equipment manufacturers giving every preference to the following types:

Type D—Lead lined steel tank having lead coils at each end, each for both heating and cooling (Fig. 1). Where coils are placed at both ends, the bulb should best be located at the back center. Some buss bar arrangements will not permit this. In such a case, place the bulb at center of end or back corner, directly in front of coils.

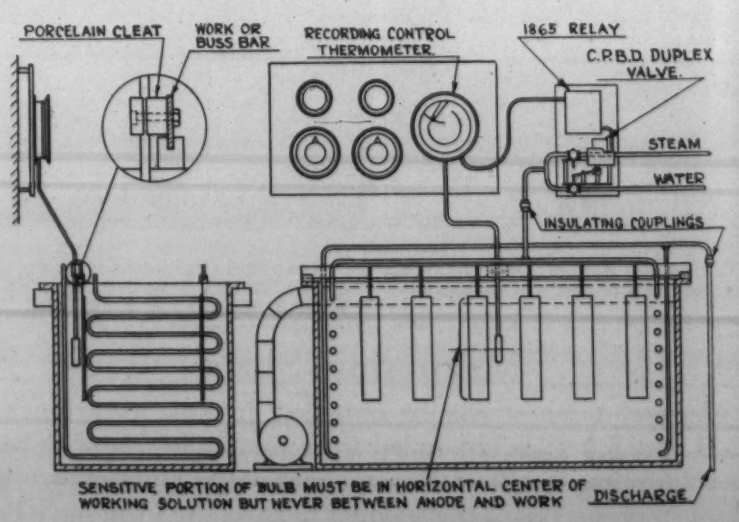


Fig. 1

Type E—A single coil along the back side for both heating and cooling (Fig. 2). Tanks with one coil at the back should have the bulb at either the end center or directly in front of the coil at the back center, depending on the buss or rack bar arrangement.

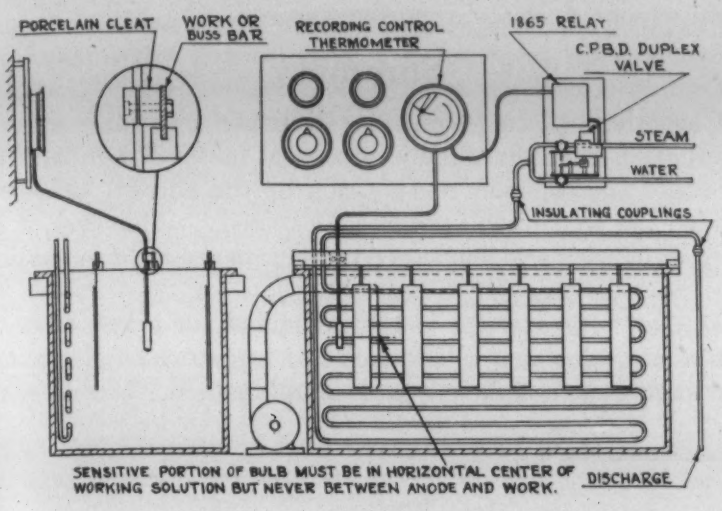


Fig. 2

Type F—A heating coil on the back and a cooling coil on the front (Fig. 3). This type should also have the bulb at either the end center, or directly in front of the back coil at back-center, depending on the buss or rack bar arrangement.

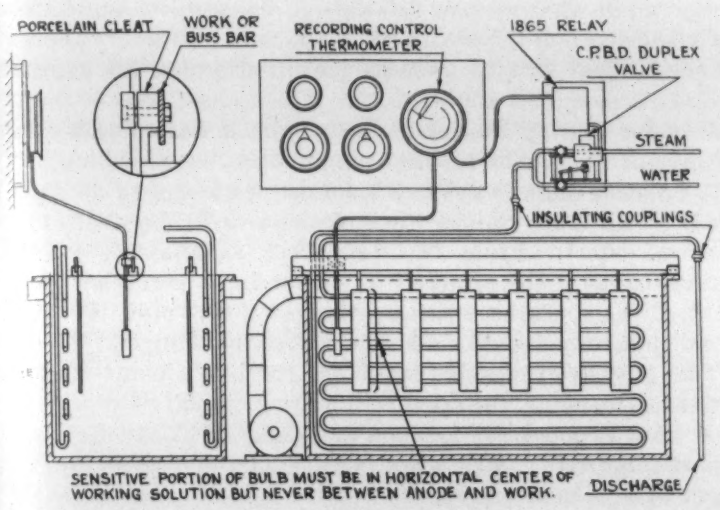


Fig. 3

Type G—The ideal combination would be a separate heating and cooling coil at both ends or one or both sides, depending on their adaptation to the arrangement of the buss or work bars across the tank (Fig. 4). With this arrangement of coils, the bulb should be placed preferably at the back center when the coils are at the ends, or at the end center when the coils are at the front or back or both. If necessary due to the work and buss bar arrangement this bulb location may be reversed.

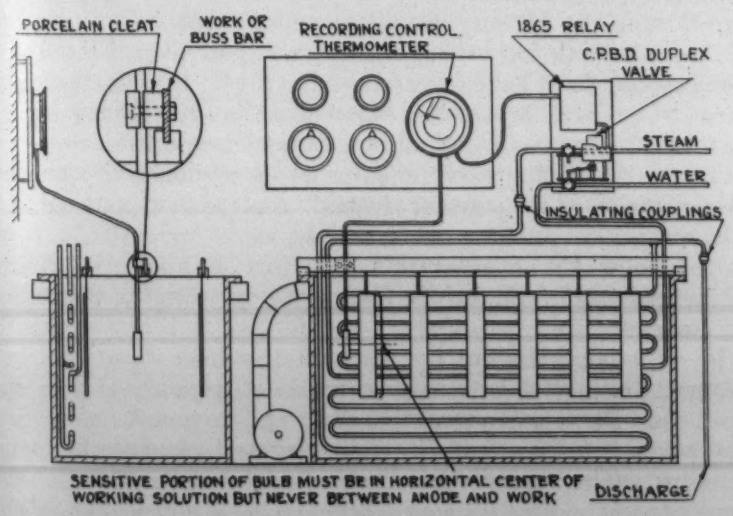


Fig. 4

In any event, the sensitive portion of the bulb should be placed in the horizontal center of the active working section of the solution. This is essential to get the best average temperature and the quickest indication of temperature change. Never place the bulb between the anodes and the work.

There is no essential difference in tanks having coils at the ends from those having coils at the sides—merely the manufacturers adaptation to accommodate fume removal ducts on the wider tanks without increasing the pull required by the exhaust fan. The heat transfer for all practical purposes is the same.

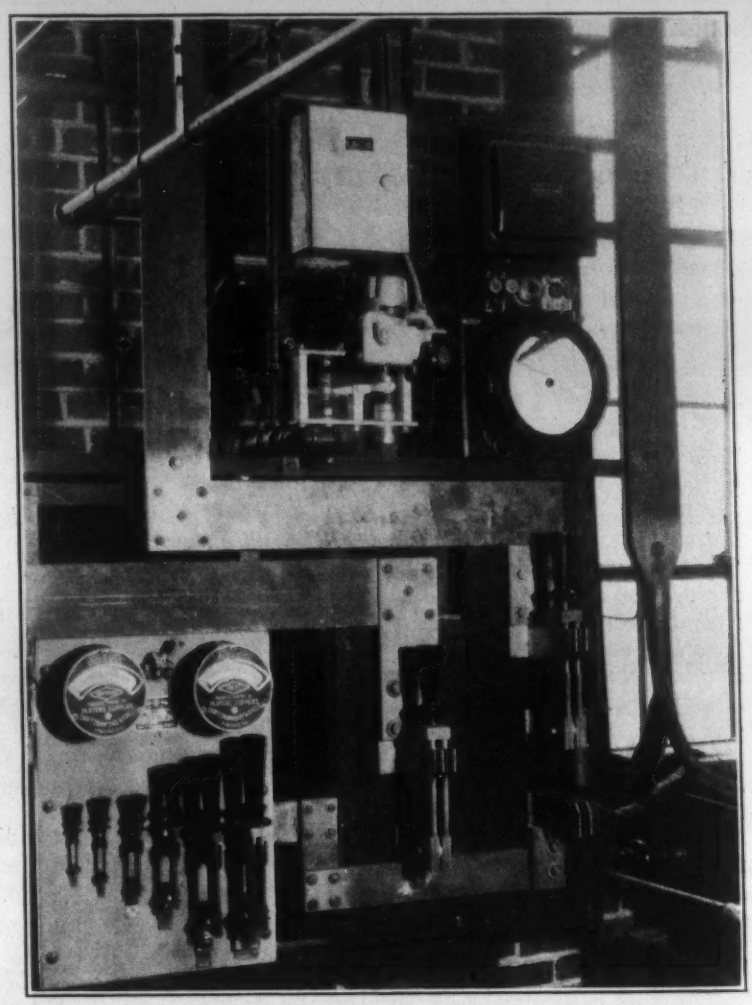


Fig. 5—Typical Instrument and Mechanism Layout

The Brown Instrument Company has found that the following equipment specification covers the usual installation in a satisfactory manner.

Item	Model	Description
1	855-2	Recording Control Thermometer (A) Chart 60-130° F. (B) Bulb No. 13736—36″ long with 6% Antimony Lead Covering (C) Tubing——ft. 6% Antimony Lead Covered
2	1371	Charts
3	12094	Ink
4	1865	Relay——volts——cycles
5	C. P. B. D.	Valve Mechanism (A)——volts——cycles (B) 2 Type 201——Valves
6		Instructions

Circulation is normally taken care of by the gassing of the solution in the process of plating. Where work being done is smaller than that for which the tank was designed, mechanical agitation is provided, or compressed air is let into the solution. Agitation does not affect the plating.

This trend in equipment specifications shows very clearly that for good chromium plating there must be even distribution and transfer of heat. If a few degrees difference due to improper distribution will give poor results, it is a natural conclusion that deviations of temperature at intervals of time as well as temperature differences within the tank will likewise give poor results.

Some equipment manufacturers lay great claims for a wide plating range of plus or minus 10 or 15 degrees Fahrenheit with equally good results. At the same time, these manufacturers stress the extremely even distribution of heat obtained with equipment of their specifications. If a wide plating range were possible, even distribution within the tank would seem unnecessary. However, if extremely even temperature distribution within the solution is essential, so also is a narrow temperature control limit, because this, in reality,

is distribution of temperature in terms of time as well as position.

Temperature control is a vital factor.

Precautions

Platers should guard against closed coils where the steam is returned to the boilers. One small leak in the coil will result in the plating solution being drawn back to the boiler and the boiler will be ruined by the action of the solution. All coils should be seamless and all joints made outside the tank.

Installation Suggestions

It is advisable to install a union and valve in each line to and from the valve control mechanism, with a by-pass line and valve around each, for both heating and cooling. With this arrangement, in an emergency, the mechanism may be removed without interrupting the process.

While the motor and limit switch are totally inclosed and the exposed parts cadmium plated, the mechanism should be protected as much as possible from corrosive liquid or gases, moisture and dust.

The relay panel should be installed in a dry place, away from vapors, dust and corrosive gases.

Summary

Chromium plating controls eliminate only the evils of fluctuation in the extremely important factor of temperature. If either the solution composition or the current density is wrong, the control will not effect a remedy. However, if the current density and solution composition are right, a *temperature control* is an *absolute necessity*.

Duplex type control is recommended, in every case, for chromium solutions. With nickel or copper plating solutions, the single type is sufficient and should be used.

Industrial Progress Made through Research[1] Its Economic Importance

By Willis R. Whitney[2]

"We live in a wonderful age. Someone has said that man has made greater advancement in the last hundred years than during his whole previous existence.

The last century was the greatest century of all time in material development, in mechanical invention, in scientific discovery and in the application of natural elements and forces of the uses of man.

But the discoveries and inventions of the present century indicate that we are moving foward at a pace surpassing all previous records.

The year 1929 will be another milestone of achievement along the broad road of everlasting time. It should surpass all previous years in material progress. That it shall do so must be our high resolve."

This is not a leaf taken from the notebook of some isolated dreamer, but is quoted from the printed menu of the dining car of one of our main railroads. It is thus becoming a rapidly spreading idea.

Moreover, men of every age have had the same impressions and the consequent urge to push forward. Nevertheless, we can safely say that never before has the world's outlook for intelligent appreciation of possibilities been as great as it is to-day.

Industrial research may be variously defined, but as it is entirely a matter of change, its meaning to different industries will vary with its application. Research is a parent of industrial growth, the other parent being the will to live better. With this simple pedigree, there is no ground for the mystery in which research is sometimes shrouded.

There was a time when most work was actually enforced by hunger or other animal needs. Men, obliged to work or starve, felt the continuous pressure as external and, therefore, distasteful. So there developed an hereditary tendency to dislike extra work. This is happily proving to be a recessive, not a dominant trait, and, moreover, there grew up a persistent counter-trait, sometimes called "monkeying," but better described as interest, inquisitiveness, and constructive appreciation. This counter-trait is successfully opposing inertia, and bringing about effective amelioration, with reduction of physical labor, for it constructs pleasure and happiness out of experiment and research.

Gradually, with the development of experiment, it seemed that man was partaking of the attributes of the Creator. Things in his environment which he did not like, he found that he could change. His efforts, at first directed to his necessities, later turned towards testing the possibilities about him. He began to see that endless discoveries could be made, and while he could never actually create anything new, finding things new to him was eminently gratifying. Rearranging his discoveries became a never ending pleasure, akin to creating.

This rearranging process expanded continually and became the most characteristic mark of mankind. His work on stone, to secure weapons for use in the never ending struggle for food, is preserved in what we now call paleolithic artifacts, and this work early showed him the flexibility of the most refractory things and so encouraged him to increase his questioning, his experiment and the consequent applications. The transference of the warm hide of fur-bearing animals to his own back was another early rearrangement. While his first manufacture was for bare necessities, he later found ways to economize work and to do with mechanical aid many things which had formerly required excessive physical effort. From the very first experiment, everything seemed to favor the principle of change for still further improvement. The more he arranged things to suit him, the more he found that they could be advantageously rearranged.

This growth of creative spirit has reached a point where men now heartily enjoy working as men never had to work before. This work is not solely for food and shelter. That need is often almost forgotten. Men work because of the artistic or creative urge. They have proved it worth while to analyze their environment and to learn by experiment what additional wants and acceptable products can be created. It is no longer a question of surviving, but of better living, and experience has shown that there are unlimited assets in the provisions of creation still entirely untouched.

It is as though we had awakened to a new faith, a faith in the exactitude and invulnerability, the certainty and reliability of countless natural laws, and in the limitlessness and flexibility of their applications. We must hold to the proper use of these laws as the work for our new faith.

As long as the whole effort of an individual was only just sufficient to insure his survival, little could be spent in preparation for more remote interests. And even a pair of protected cave-dwellers could not have been advised to divert the efforts of one of them to research before the other could provide living for two. But as time passed, and organizations developed, these grew large enough so that each member was a specialist of some sort. One planted when another reaped, and some produced what others sold.

Nowadays the coordination of effort is such that certain specialists may confine their work entirely to the possibilities of the future. The tendency is to look farther and farther ahead.

In all civilized countries research has had about the same history. It received its earliest impulses from those who spent most time in constructive thinking, and so monks were found producing new knowledge in chemistry and physics and even in heredity. The organized centers of higher education in every country soon became the source of much basic physical knowledge. Time more or less free and inquisitiveness more or less encouraged gave opportunity for the discovery and publication of new facts, and the principle of broadcasting new knowledge became fixed in all lands.

We see this in the lives of Joule, Ampere, Ohm and Volta, for example, where England, France, Germany and Italy respec-

[1] A paper delivered at the World Engineering Congress in Tokio, October 1929.

[2] Vice-President and Director of the Research Laboratory, General Electric Company.

tively are represented, and similarly again in Oersted, Henry and Huygens, representing Denmark, the United States and Holland. Cavendish, Bertholet, Bunsen, Avogadro, Berzelius, van't Hoff, and, again Davy, Pasteur, Liebig, Cannizzaro, Scheele, Van der Waals, are similar groups of representative chemists from the schools of six different countries. Their researches proved to be the foundations on which world industries now tower. But none of these men aimed at the solution of pressing technical problems, though the application of the researches of Pasteur, for example, quickly demonstrated the value of academic studies.

Perhaps in no one case is the effect of long continued academic research more in evidence than in the chemical industry. For a half century the study of organic chemical reactions, without reference to industrial applications, was carried on apparently only for the stimulus which new and exact knowledge gave the minds of men interested in education. Germany in particular, through the researches of countless young doctors of philosophy, gathered a fund of new organic chemical facts upon which enormous and varied industries were established.

The study of physical laws also showed at an ever increasing rate that intelligent experiment, which brought us the steam engine, the spinning frame, the printing press, the electric generator, and thousands of other advances, could reduce hard labor and increase happiness without limit. Each new industry continued to find within itself additional means of improvement. They were all based on the creative instinct of men who were not too heavily hampered.

Still more modern devices and industries well illustrate my point. No one of the many leaders in the automobile industry, for example, started manufacture or continued improvement because of the hunger urge (sometimes, indeed, in spite of it). The race has continued along the promising and endless road of appreciation not under the goal of necessity, but under the beckoning and growing light of understanding. Call this the creative urge or the encouraged inquisitiveness of a changeable animal, the direction and the outcome are the same. We easily fix it into our conception of what is right.

It now runs counter to our instincts to neglect buried treasure. Our experience assures us of an infinite wealth of still undeveloped science. The indifference of millions of people is completely offset by the inquisitiveness and appreciation of individuals. The minds of some have got so far along in variety of specialization and creative will that there need be no end to industrial research.

The experience of those first free-moving cells which came together in the favoring warmth of ocean depths and found those particular functions which each could best perform in the new organism, is copied to-day in human organizations. Thus, we speak of the "increasing functional efficiency of highly specialized units in the division of labor in society" with the same words which were applied to the colony which first developed into a jelly fish. In this respect the industrial plant still resembles the simplest known living plant.

There is some danger of over-popularizing industrial research and also of overdoing the use of the term. The result of attracting special attention to research may be to suggest something essentially false, like a general panacea for work or a cure for all economic ills, and so induce unprepared people to undertake ill advised work. The excessive demand for scientists in very recent years has indicated such misconceptions.

We overdo the use of the term "industrial research" when we apply it, for example, to the testing of materials in order to check up on specifications. That it is not. It is something designed to discover untested materials and processes, to bring about better use of old materials, to reveal new wants, create new desires and actually predetermine new needs. One might even say that its aim is to perpetuate dissatisfaction with things as they have been and insure open ways to unlimited change. It is continually digging out of the universe new things recognized easily, after the event, as indispensable. One of its aims is to anticipate and predetermine our wishes, so that established manufacturers may, by improving methods or products, continue to grow.

It is a matter of experience that most manufactured articles are sooner or later superseded by others. The new may be entirely different from the old, or may differ only in the method of production, but the successful manufacturers are those who are prepared to change one or both of these criteria. There is no inherent reason why a manufacturing organization need disintegrate merely because a particular product which it once produced is displaced by something better. There are firms which still manufacture the tintypes of years ago, the tallow candles, the ox-yokes and the tin bathtubs, but if they are also making the photographic films, the electric lamps, the farm tractors and the porcelain bathtubs they need not suffer extinction.

It is not contended that industrial research is the key to all human improvement, though general research may be. We might even admit that the Greek civilization, over a period of two hundred years, exceeded our own in the apparent interest in all art and in the tendency to live intelligently. But it is for our age to discover and remove the obstructions in the road to better living in the future. In this, industry must help. New engineering involves making and moving everything more quickly and easily, whether it be man's thoughts or the products of factory or soil. This effective shortening of time and distance also helps to obliterate differences in custom and in tongue, and thus eliminates ground for misunderstandings. We ought to anticipate for the whole earth's surface the experience of village development where natural economics and general welfare persist in cooperative peace, and a single constable is also dog-catcher, fire-chief and postmaster.

Bergson wrote that the essential object of science is to enlarge our influence over things. "Science may be speculative in its form, disinterested in its immediate ends; in other words, we may give it as long a credit as it wants. But however long the day of reckoning may be put off, some time or other the payment must be made. It is always, then, in short practical utility that science has in view."

One of the leading merchants of the country, Mr. E. A. Filene, of Boston, recently wrote: "The big volume of luxuries, comforts and necessities which we produce and consume has been largely due to research, to an application of the same scientific methods in the conduct of business as have been so successful in medicine, biology, physics and astronomy." In other words, specialists advanced our knowledge by careful experiment, and to-day, in our production and consumption of luxuries, comforts and necessities, we are scientifically more active than ever before.

Medicine, always the product of experiment, has become more and more orderly. Never was there a time when new chemical compounds and applications of new principles were being so generally studied, and new ones beget others. Biology, with its researches in the growing cell, has enormously increased our understanding of living processes even to the mechanism of heredity. It has placed in man's hands new instruments for an extensive line of useful researches, and never has there been so much value in sight. Physics, through relatively simple experiments, has done more in the past two decades to inform us about the nature and properties of matter than in all preceding time. It has been marked by theory and speculation, but largely by a kind of speculation which was at once capable of material investigation, and now there is more promise than ever. Astronomy, a science which has always called for the utmost credulity, has advanced through relatively simple researches supporting exceptionally radical speculations, and with its increasing dimensions it still supplies principles of similitudes which are exceedingly fertile and necessary for interpreting modern scientific conception of matter, and here, too, is more of interest just within reach than at any time. And so it must be with industries. They will develop not alone greater economies and more complete substitution of mechanical power for human effort, but they will disclose with new discoveries those unexpected utilities which come from the interlocking of new knowledge in different fields.

A brief reference to the growth of industrial research in America may not be out of place. To a great extent any history depends on who writes it, but certain general facts of American growth are obvious. Doing new things intelligently ought to come from research. The general sequence is very old. But as mechanically empowered industry may be called a development of the last century, so organized industrial research may be attributed to the present century. The United States has taken part in both activities. At the beginning of this century there were practically no industrial research laboratories in the United States, and the word "research" was almost exclusively confined to college and university. Now a recent report of the National Research Council lists a thousand research laboratories independent of colleges and government bureaus. Three hundred were listed in 1920. This connotes a change that is affecting industry as definitely as the introduction of steam, for intelligent

interest in industrial research is by no means confined to the United States.

It would not be difficult to picture the influence of organized research in such active industries as aeronautics, electricity, automobiles or radio. These are *in toto* entirely modern. Here many youthful and inquisitive minds see the light and feel the creative force. Their work has been well advertised. But in looking over the laboratories of the country one sees how it has also been with less popular things. For example, as organic chemical knowledge progressed a very few explorers attacked the chemistry and physics of cellulose. Here was one of nature's most widely spread products. It seemed to be so complex, when compared to the simple compounds which chemists had already understood and synthesized, that few were bold enough to attack it. But Tollens, Fremy, Ost, Schwalbe, Chardonnet and Cross and Bevan were such pioneers, and now we see that wood pulp, the cellulose mine, is continually yielding new products. Its chemistry and physics are being widely studied. It is being applied for sound insulation and for insulation of heat. It is used as a cotton substitute in high grade paper, and even modern silk is made of it. It is used in explosives, and also for non-inflammable movie films. It threatens to displace bone and ivory except where they are actually born, and it is displacing the vehicles of varnishes and paints. These new cellulose products did not come through an increase in the rate of grinding wood, nor because trees began to grow faster. They did not come because pulp tonnage produced new markets. They came because the researches of purely inquiring minds supplied new knowledge and altered points of view. The industry was lifted by new levers. The leverage was the work of research chemists who began devoting their lives to the study of cellulose. They purified it, they dissolved it. They tried every conceivable reaction with it. They hydrolyzed it, they nitrated, sulphided and sulphated it. They fermented it, they coagulated it, they precipitated it. They studied it as a colloid and they studied it as a crystalloid. They studied each new cellulose compound as to any possible interest it might have. They established an extensive literature covering several decades of careful observations. It is not surprising that there should be many possibilities of service in what, in radio, would be called "new hook-ups" of the established knowledge. This illustration may not be as standardized as some that might be taken from modern electrical developments, but I use it as a conservative and generally applicable example of industrial research as it is actually carried out.

A generally similar effect of research can be found on many sides, but it seems usually true that the more modern the industry the more extensive is the application of research to it. Coal, iron cotton, wool, leather and ceramics seem less thoroughly cultivated from the research standpoint than such corresponding, but slightly more modern subjects as petroleum, aluminum, cellulose, dyes, rubber and paint. In the former group the efforts to produce in large quantities apparently postponed the pressure of research work.

But even with the older industries many marked effects of research have resulted. The Corning Glass Company has given us glass cooking utensils which the new knowledge of controlled expansion coefficients made possible, and very recently paraffined paper bottles have been introduced in New York to reduce the cost and increase the cleanliness of bottled milk. Countless new solvents are now being produced through researches on petroleum, and by the study of gaseous combustion, an enormous field of cutting and welding steel has been developed.

Modern research applied to the paints, varnishes and enamels used by industries interested in automobiles, radio sets and power refrigerators has produced many more satisfactory products than were the earlier metal coverings. The modern field of the photographic industry somewhat resembles radio in being based entirely on active research. Every year brings out new photographic improvements, the silent drama, the talking movie, the colored movie, and soon the talking colored movie, while the radio finds new generating and receiving systems through continuous researches in electronics.

It is easy to speculate in industrial futures, but to do it carelessly is not industrial research. Every industry interested in future growth should devote to scientific research a small fraction of its profits. But what fraction shall it be? Experience and not experts should decide that, bearing in mind the possibility of a greater investment by competitors.

Attached as I have long been to an industry in which active research is a habit, I cannot fix in my mind any upper limit to useful novelty, though I can for the rate at which it may be sought. For that reason I am interested in the statement of Haldane, the biochemist: "It is quite likely that after a golden age of happiness and peace, during which all the immediately available benefits of science will be realized, mankind will very gradually disintegrate." This seems based on bad arithmetic. I hope that the golden age of happiness and peace will forever be the one just ahead of the present and that for which man can forever prepare. There are several hundred thousand years of experience which warrant this hope. I think that the world can no more realize "all the immediately available benefits of science" than one could realize the volume or capacity of an infinite pyramid by starting blindly to creep along one of its outer edges.

But if we confine our estimate of the importance of industrial research to a survey of material benefits, we lose sight of what may well be its supreme achievement. For industrial research affects our creeds. Biology shows us how far we have come from the amoeba, and shows us, too, the kind of cooperative effort which insured the advance. We may, therefore, believe that when research is utilized by all industries, natural by-products will be further mental development, more serviceable idealism, fuller understanding among peoples and better direction of the affairs of nations.

What is being learned from science, specialized for industrial needs even of sordid kinds (experienced but perhaps not always recognized), is that impartial and truthful experiment is more serviceable than any amount of emotional persistency or unemotional fixity. While scientific research continues to extend naturally, and men feel the value of newly acquired material knowledge and truth, the possibilities of improvement in more important human relations than industry through painstaking, impartial analysis and constructive, forward-looking synthesis will be realized.

Copper's Service to Industry

Copper's role in meeting the increased demand for machinery and for manufacturing materials, resulting from the application of power to industry, is described in a special issue of the bulletin of the Copper and Brass Research Association, 25 Broadway, New York, featuring "Copper's Service to Industry."

"Copper's part in manufacturing is not always evident to the consumer," the bulletin states, "for some industries employ the metal in making products which do not themselves contain it." An example is the printed page, the type for which is usually cast automatically from brass matrices. About 500,000,000 of these brass matrices are in service to-day in newspaper and general printing plants throughout the world.

"Some industries consume copper that becomes an integral part of the completed product, as in the manufacture of clocks and automobiles. Fabricating activities of this kind use copper both in the product itself and in the machinery that turns out the product." One of the leading clock and watch manufacturers alone consumes about 1,150,000 pounds of brass annually. A single rapid transit system in New York requires 650,000 pounds of copper, brass and bronze each year for service use, in addition to more than 2,000,000 feet of copper wire and cable. Feminine vanity creates a market of 25,000 pounds of copper a year in the manufacture of rouge boxes and compacts by one firm.

Clothing manufacture calls for an extensive use of copper and the metal performs many services in the textile industry processes of dyeing, washing, bleaching, drying, printing, pressing and calendering. The estimated annual increase in electric horsepower used by textile mills indicates that the industry is responsible for a yearly consumption of about 6,300,000 pounds of copper for electrical purposes alone.

"Seventy-five percent of American industry is now electrified. Hence, before an ounce of copper is consumed either as mechanical equipment or as parts for products, the average industry is already employing copper for the transmission and use of power and frequently also for its generation."

"Power, through its expansion of industry, has been a factor indirectly responsible for the steady growth of the markets for copper, brass and bronze. With the application of power to industry, the need for machinery and for manufacturing materials increased. In supplying this need the producers and fabricators of copper have played an indispensable part."

Ocean Shipment of Ferrosilicon*

Summarized from a Report by the Bureau of Mines and Bureau of Standards to the Steamboat Inspection Service

The regulations of the Steamboat Inspection Service formerly forbade the shipment on passenger vessels of ferrosilicon whose silicon content lay between 15 and 80% silicon. Little ferrosilicon is exported from this country, so that the regulations seldom have to be applied, but a situation recently arose in which a rush shipment of ferro of about 75% needed to be made without waiting for the sailing of a freighter.

Since all who are acquainted with ferrosilicon seem to agree that there is no hazard of phosphine evolution from a ferro with more than 70% silicon, and ferro of over 70% may be shipped on English passenger vessels, it was evident that the regulations needed revision. The Steamboat Inspection Service requested a report on the hazards in shipment of ferrosilicon from a special committee of the Bureau of Mines and Bureau of Standards.

This committee collected information from the literature and from all domestic producers. Its report, slightly condensed, follows.

"Some 25 years or more ago, a shipment of ferrosilicon over the North Sea disintegrated in shipment, gave off poisonous gases and caused fatalities among the men on the ship. Ferrosilicon manufacture was in an embryonic stage at that time and the cause of the difficulty was not known.

"Since that time this matter has been ever before the eyes of ferrosilicon makers. At one time the leading French producers agreed to drop production of the grades between 30 and 40% silicon and between 47 and 65% silicon, as dangerous grades. These limits were probably set so as to be sure to eliminate the ranges 33–35% and 52–55% which have been the actual ranges most generally thought to be dangerous.

"Hake, in the British Yellow Book on the subject says that while the 33–35% silicon grade is alleged to crumble, he has been able to find no proof of this.

"In England, the range 30–70% has been proscribed from ocean shipment on passenger vessels, and most text-books mention the range 30–65% Si as dangerous.

"Nevertheless, the standard commercial grade of ferrosilicon is a nominal 50% silicon. Another important grade is a nominal 75% grade. Still higher grades find some special uses.

"The facts seem well established that regardless of impurities, any ferrosilicon that would be commercially acceptable nowadays from other points of view, carries no shipment hazard within the range 0–30% or 70–100% silicon, and that a 45% grade is probably also free from hazard. It is equally definitely established that in the range 52–55% silicon, there is a real danger which cannot be certainly eliminated without going to excessively expensive precautions, and even then, there seems little certainty that the precautions would always be effective since so many unknown variables are involved.

"Ferrosilicon is a general name for an alloy of iron and silicon. Any composition might find metallurgical use to introduce silicon into iron and steel. Pig irons or ferro with silicon up to perhaps 16% silicon, known as 'silvery iron' or Bessemer ferrosilicon are made in the blast furnace. A large production of this grade, and all the commercial alloys higher in silicon, are made by electric smelting. Silica rock, sandstone or similar rock consisting of nearly pure silica is reduced by coke in the electric furnace in presence of iron ore, or, more commonly, steel scrap.

"Most impurities in the steel scrap will tend to remain in the ferrosilicon, as will reducible impurities in the silica rock. The temperature required for reduction of silica is high, which is the reason for the use of the electric furnace. The furnace is operated with comparatively little slag, and there is, therefore, little purification in the smelting process.

"Ferrosilicon is a cheap, tonnage product and no chemical purification of the raw materials is economically possible, even when the purest commercial silicon metal is being made for use in aluminum silicon alloys. The purity of the product has primarily to be controlled by selection of raw materials and, to a lesser extent, by control of furnace operation.

"The steel scrap used (or the iron ore when that is used) always contains some phosphorus. Since cast iron borings and Bessemer steel scrap are relatively high in phosphorus, the added iron is usually open hearth steel scrap, in order to keep the phosphorus down. Depending on the percentage of silicon in the ferrosilicon, the phosphorus content of the ferrosilicon cannot, with the purest of raw materials, be brought below, say, 0.01–0.03% on account of the phosphorus introduced by the steel scrap. Moreover, the sandstone or other silica rock always contains some very small amounts of lime and alumina and some of the lime may be combined as calcium phosphate, in which case the bulk of the phosphorus in the calcium phosphate will be reduced to enter the ferrosilicon. Some of the alumina is reduced to aluminum, (which forms the chief impurity in ferrosilicon) and a small part of the lime is reduced to calcium. Choice of sandstone for use in making ferrosilicon is based quite largely on its calcium and phosphorus contents. Some impurities come from the ash of the coke or other reducing agents used.

"Depending on the composition of the raw materials and the temperature at which the reduction is carried out, ferrosilicon thus contains (beside iron and silicon) aluminum to the extent of perhaps 1–2%; calcium in much smaller amount; and phosphorus to the extent of a few hundredths of a percent. As noted above, the phosphorus may be present as iron phosphide, aluminum phosphide or calcium phosphide or combinations of these.

"The condition of the phosphorus may vary so that an analysis for phosphorus does not necessarily show whether it is there as iron phosphide, aluminum phosphide or calcium phosphide.

"Iron phosphide does not react with moisture, but aluminum phosphide does, while calcium phosphide reacts with moisture very rapidly.

"In the presence of moist air, phosphorus is readily removed from the surface of ferrosilicon. If the ferrosilicon is allowed to stand in ordinary air for a few days so that the surface phosphorus is removed there will be no further rapid evolution of phosphine unless the ferrosilicon is crushed, broken up or disintegrated so as to expose fresh surfaces. Slight breakage of lumps will occur in handling even packaged material.

"Phosphine in high concentration will take fire spontaneously. It is not evolved rapidly enough from ferrosilicon to make the flammability a real danger, but even in low concentrations it is poisonous. In closed containers there is a possible explosion hazard. However, unless the ferrosilicon is freshly crushed or is in process of disintegration in some other manner there is no hazard in its shipment because the great bulk of the phosphorus has been removed from its surface by action of the moisture in ordinary air before the ferrosilicon can leave the plant where it is made.

"Were there no tendency toward a spontaneous disintegration of ferrosilicon, which would present fresh surfaces to the action of moisture, there would be no hazard in the ocean

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shipment of ferrosilicon. However, some ferrosilicons do disintegrate.

"Disintegration is at a maximum at 52–55% Si. Askenasy says that 50% Si ferrosilicon evolves gas on contact with moist air, the gas containing 10–15% PH_3, but the total gas evolved by the best grades of 50% ferro is very small and danger of poisoning correspondingly remote. With the same impurity content, the amount of gas given off depends on the crystal size. Rapidly chilled ferro, with very small crystals, gives off practically no gas, while slowly cooled ferro, with large crystals, gives off more. (Chemical analysis alone, therefore, will not appraise the danger or lack of danger.)

"Askenasy says that any ferrosilicon below 50% Si, even if made from impure materials, gives off but little gas. At 52% Si the ferro crystallizes in large leaf-like crystals and such ferro tends to crumble. Unless extreme precautions are taken in choice of raw materials or unless the ferro is very rapidly chilled, any 52–55% Si ferro may crumble, and in so doing rapidly expose fresh surfaces to the moisture of the air, PH_3 being rapidly evolved. Copeman also says it is only the 50% grade (actually 54–55% Si) that is dangerous.

"While some ferros in the 52–55% Si range are known not to have disintegrated although exposed to moisture for years, it is apparently not known exactly what the difference is between those that crumble and those that do not. By using extremely pure and expensive raw materials and by chilling rapidly, it is possible to make ferro in the 52–55% range that will not crumble or will not contain enough phosphorus to cause trouble if it does crumble, but since there is no metallurgical need for this exact composition, the remedy stated by Askenasy in 1910, not to make 52–55% Si alloy, but to keep the Si content below 52% or above 55% is the one still adhered to throughout the world.

"Askenasy points out that the crumbling tendency rapidly decreases as the Si content rises above 55%. Askenasy says a very slight tendency toward crumbling can be noted up to 75% Si, but that above that Si content, there is no tendency at all toward disintegration even with large amounts of impurities. United States producers who have discussed this matter with the committee have not seen any such tendency in the 70–75%, or higher, alloy.

"A recent paper on the iron-silicon equilibrium diagram is that of the Japanese worker, Murakami. Earlier diagrams were due to various workers, among them the Russians, Kurnakov and Urasov. Their diagram, slightly modified by the German metallurgist, Tammann, shows two fields from 33.7–61.5% silicon which enclose the zone of real danger 52–55%. It seems probable that the 30–65% or 30–70% prescribed zone was originally set up from the idea that since these fields include the danger zone, both these fields and a little more so as to get round figures, should be excluded.

"But later work by Pharagmen in Sweden has materially modified the diagram. His diagram indicates that at around 35% and at 52–55% Si the 'duralumin type' of heat-treatment may be applicable—that is, depending on conditions of heating and cooling, alloys of the compositions shown by those lines, may or may not be stable.

"Murakami's diagram differs from Phragmen's in showing no curving lines, but agrees in showing two solid-solution fields at 33–35% and 51–53%.

"Murakami worked with alloys rather high in phosphorus; they were made up from pure iron and a ferrosilicon with over 90% silicon and nearly 0.40% phosphorus. His 50% silicon alloy would, therefore, contain about 0.20% phosphorus, while commercial alloys of this grade would normally not contain half that amount of phosphorus. He does not state the calcium content of his alloy. He mentions nothing in regard to observations on disintegration of his alloys and apparently did not meet the phenomenon.

"There are no data on how impurities such as phosphorus, calcium and aluminum may affect the equilibrium diagram. It should be noted, however, that the diagrams of both Phragmen and Murakami, representing the best recent work, indicate no liklihood of any phase change that would result in disintegration of the alloy of 45–50% silicon.

"Observations of producers of ferrosilicon indicate that disintegration of ferrosilicon and evolution of poisonous gas are two separate, although inter-related phenomena. Disintegration appears to be due to some internal phase change which takes place with change of volume and thus results in the crumbling of the material. Slowly cooled ferrosilicon appears to be more susceptible to crumbling than rapidly cooled material. This would be explained by the more effective 'super-cooling' on rapid cooling, producing a finer grained material.

"The gas evolution is due to a reaction between moisture from the air and impurities on the surface of the alloy. If calcium carbide were present, disintegration would follow because it reacts readily with moisture, to form acetylene and it has been suggested that the difficulties with early production of ferrosilicon may have been due to making the ferrosilicon in an electric furnace previously used for making calcium carbide. However, there would be no true solubility of calcium carbide in the ferro and the carbide explanation is far-fetched since only barest traces of acetylene are reported in the gas given off.

"The use of a calcium carbide furnace might, however, increase the amount of metallic calcium present, and this is doubtless disadvantageous.

"The poisonous nature of the gas evolved is without question due to the presence of phosphorus as impurity in a form attackable by moisture of the air, to form phosphine.

"If arsenic is present as calcium arsenide the gas arsine AsH_3 which is poisonous also, may be similarly evolved, but the amount of arsenic in the raw materials used is small, and it is very doubtful if arsenic plays a part in the problem.

"If disintegration is under way and the lump of ferrosilicon is starting to crack up, entrance of moisture into cracks would generate gas by attack on the attackable phosphorus on the new surface and the pressure of this gas may exert a wedging action which would accelerate the disintegration. The 52–55% silicon grade has a more 'open' crystal structure than some of the denser grades such as those with 30 or 70% silicon, so that it is not quite clear how much of a part entrance of moisture between the loosely-arranged crystals may play. However, a grade that will crumble in the air will also crumble in a closed container, so that the main action in crumbling seems to be operating from the inside of the alloy itself rather than from the outside.

"Since calcium phosphide is an obvious culprit in the formation of poisonous gas, attention has been centered on it. There is a possibility that aluminum may play a part, but the evidence as to its action is quite indirect. Aluminum phosphide would react similarly to calcium phosphide. Aluminum is present in varying amount, from about $^1/_2$–2% or more in electric furnace ferrosilicon.

"Iron phosphide does not react with water, hence, the total phosphorus present as shown by chemical analysis is not a measure of the attackable phosphorus.

"Calcium and phosphorus are the impurities that it is found necessary to guard against most carefully in order to prevent disintegration of the 52–55% ferrosilicon, but no definite limit can be set as to permissible amounts of these impurities in the raw materials, or even in the finished product, since furnace temperature and the rate of freezing of the ferro also play a part in the formation of attackable phosphides and in the stability of the ferro.

"It appears that the 52–55% silicon grade should not be permitted in ocean shipment at all.

"There is no restriction on interstate shipment even in this grade because the trade will not take a material that crumbles, and there is essentially no intentional manufacture

of alloys with that range of Si content. Federal Specifications Board, Specification No. 172, lists three grades as follows:

Grade A 70–80%
Grade B 45–55%
Grade C 10–20%

It is specified that if special packing be necessary to secure the acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery, such packaging shall be provided by the contractor without additional expense to the purchaser.

"The 45% Si is certainly safe and 50% may actually be so. In a lot of ferro averaging 48% Si, however, it is possible that segregation, or a few furnace taps on the high side in Si content may bring part of the lot a little above 50% Si. The tendency toward crumbling seems to fall off very sharply from 52–50% and somewhat more slowly from 55–60%. The 70% is surely safe. For this reason, while it might be necessary only to ban the actual 52–55% range, it seems wise to widen the prescribed range to cover the range 48–65% Si, so that variations in actual composition of different parts of lots averaging 48 or 65% may not run into the danger zone. With the 48–65% range banned, commercial demands for uniformity will hold variations in composition safely away from the zone of real danger.

"Several manufacturers would much prefer to make a ferro with 48% average silicon content rather than 50% since the danger of running high enough in silicon to get into the 'disintegrating range,' would be much reduced. Apparently the only reason why consumers want the material to contain 50% silicon is for ease in calculation of charges.

"Standardization on 48% rather than 50% would almost completely remove any hazard, the 45% would be still better. One manufacturer advocated permitting shipment of material averaging 50% silicon with the added proviso that no part of the shipment in 'grab sampling' should contain over 51%, but since no other manufacturer raised this point and some had commented to the effect that segregation in material averaging 48% might cause some parts of the shipment to run slightly over 50%, it appears that were the upper average for this grade put at 50%, it would require an excessive amount of analytical work to be certain that no part ran above 51%, while with the upper average at 48% there is a much larger factor of safety.

"It seems useless to impose any restrictions at all on material below 45% or above 70% Si. The only question in this connection is whether the 33–35% silicon composition is dangerous as alleged in the earliest discussions of the problem and as may be possible if Phragmen's diagram is correct.

"From statements of producers it would appear that they do not class this range as liable to crumbling, but as it is not a grade commercially manufactured in this country, it is not certain that enough actual experience is available to allow a correct decision.

"The bulk of the evidence available would indicate this particular grade to be free from hazard and since, in the committee's discussions and correspondence with producers, no evidence has been adduced that it is hazardous, it is believed that it need not be proscribed since there is little chance that it would be produced even if its shipment were allowed. This admission of 33–35% silicon ferrosilicon is the only point in the committee's recommendations which appears to it to be in the least questionable from the point of view of safety. Should this grade even become commercial in this country so that the question of the safety of its shipment should arise, the matter might have to be reopened. Under those circumstances there would be plant experience on which to base judgment which is lacking at present.

"If we then have 0–45% admitted without restriction 48–65% barred, 70–100% admitted without restriction we must next consider the ranges 45–48% and 65–70%.

"There is ordinarily no export of the 45–48% grade as foreign demand is met by foreign supplies, but since this is the common commercial grade of ferrosilicon (often called 50% but quite often, and preferably, held lower to avoid likelihood of reaching 52% in any part of the shipment) it seems desirable, in suggesting a revision of the regulation to so frame it that in case changing economic conditions bring about a need for exportation of this common grade, restrictions upon its shipment shall be no more stringent than will assure safety.

"It is believed that storage of ferrosilicon whose average analysis comes in the ranges 45–48% or 65–70% Si for one month will both remove any harmful phosphorus from the surface and reveal any tendency towards disintegration. The ferro should not be coated with oil, paraffin or other material, should be stored in the size in which it is to be shipped (and not crushed after storage and before shipment without restorage), and it should be so piled during storage as to allow free access of air.

"If disintegration has begun the lumps of ferro can be crumbled in the hand. If the lumps are not crumbly in a month they will normally never crumble. Some makers think a week's storage will reveal any crumbling tendency so a month gives a factor of safety. In the rare cases where crumbling sets in later the process will be so slow that there should be no hazard in shipment. The cases of delayed crumbling seem confined to the proscribed range and should be eliminated by the restrictions as to composition.

"The committee does not believe that it is feasible to add much to the information collected from the literature and from commercial experience, by means of laboratory experiments, since it is obvious that the condition of the various impurities in ferrosilicon is affected by furnace temperature and by the rate of cooling of the product. If a wide range of compositions with each impurity present in controlled amount, each composition made under varying furnace conditions and with various rates of cooling, were available that had been under actual full-scale commercial conditions, systematic laboratory investigation might throw further light on the subject, but the preparation of the specimens would cost many thousands of dollars. To attack the problem by making up small synthetic melts, in the laboratory, would be almost fruitless and if conclusions as to liability to disintegration and to evolution of toxic gases were drawn from them the conclusions would very probably be unsound when applied to material made on a commercial scale.

"The committee has communicated with all known producers of ferrosilicon in the United States, and makes very grateful acknowledgment to these producers, who without exception, have put at the disposal of the committee all the information that they had available and who have approached the matter in the spirit that public safety was paramount. No selfish motives have entered into their discussion of the matter. The committee has served merely as a means of collecting and correlating the experience of industry and presents the weighted means of the facts and opinions presented."

As a result of this report, the Supervising Inspector General of the Steamboat Inspection Service modified[1] the regulations as follows; responsibility for compliance with them being placed upon the carrier.

1. Lots of ferrosilicon whose average silicon content lies between 48 and 65% silicon shall not be shipped on passenger vessels. No ferrosilicon shall be accepted for shipment that has been made in a furnace previously used for making calcium carbide or ferrophosphorus unless the furnace has previously been entirely relined.

2. Lots of ferrosilicon whose average silicon content lies between 45 and 48% or 65 and 70% may be shipped on passenger vessels only when a satisfactory certificate of analysis as to silicon content is supplied to the carrier, and when the

[1] Dept. of Commerce, Steamboat Inspection Service Bulletin No. 167, Sept. 3, 1929.

carrier is satisfied that the material has been stored, in the size in which it is to be packaged and shipped, for a period of at least one month. Lump ferrosilicon shall be stored in piles not higher than 3 feet. It need not be turned over during storage. Crushed ferrosilicon (material crushed to pass a 2 inch or finer meshed screen) shall be stored in piles not higher than 18 inches and the piles shall have been turned over so as to bring the material at the bottom of the pile into free contact with the air at least once during the period of storage. At least a week shall have elapsed between a turning over of the pile and packaging for shipment. The material shall not be coated with oil, paraffin or other foreign substance.

If after one month's storage any odor of phosphine is noted or if the lumps of ferrosilicon can be crumbled in the hand, the carrier shall refuse shipment to such portions of the pile as are affected if they can readily be separated from unaffected portions, or in his discretion, may refuse shipment to the whole pile.

3. There shall be no restrictions upon the shipment of ferrosilicon containing less than 45% or more than 70% silicon—suitable certificate of analysis shall be required by the carrier to establish the silicon content.

4. Ferrosilicon shall be stowed on shipboard in a dry, well-ventilated place, so located and ventilated that any escaping gases cannot reach the quarters of the crew or passengers. Precautions must be taken so that waves, spray, rain or bilge water cannot come in contact with the packages or the ferrosilicon.

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Girard Occupies New Plant

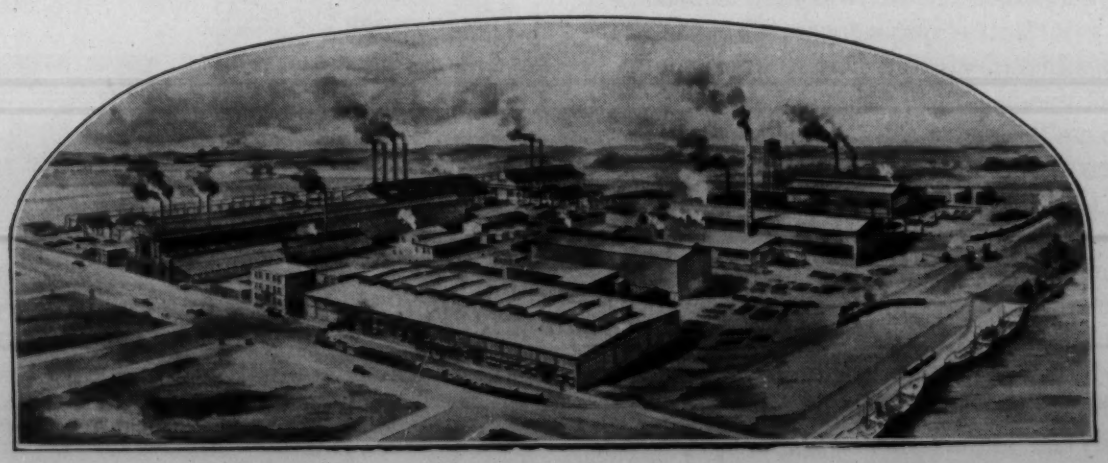
It is a pleasure for METALS & ALLOYS to chronicle success or prosperity on the part of any firm or corporation actively and prominently identified with the metal industry. Announcement has reached us that the Girard Smelting and Refining Company has recently moved into its new plant at Tacony, Philadelphia, Pa., shown in the accompanying illustration.

This plant was constructed to provide, through the installation of most modern equipment, increased facilities for efficient production of metals of perfect quality.

The Company has attracted a high caliber of employee who takes pride in producing flawless metals. With watchfulness and the aid of modern, mechanical safeguards, they have manufactured the quality of metals which has brought its attendant reward in increased business. The new plant, four times as large as the one occupied for the past two years, gives evidence of increased achievements.

The rail and water shipping facilities are excellent; necessary to care for the large shipments made to distant points.

It is evident that the Girard Company merits the use of their new slogan: "A Refinement in Metals that Leads in Quality."



Protecting Iron during Acid Pickling

An Investigation of Cathodic Treatment

By U. R. Evans and J. Stockdale*

Methods Available for Protecting the Metal in Pickling

Pickling in acids is often employed as a means of removing thin oxide-films and the like from iron articles. The main objection is that not only is the oxide-film removed, but the metallic basis is sensibly attacked by the acid.

To minimize this attack, nitrogenous or colloidal substances (such as quinoline, quinoline ethiodide, coal tar bases, gelatine, yeast, bismarck brown and a host of commercial preparations) are often added to the pickling bath; the efficiency of these different protecting agents has been compared by Chappell, Roetheli and McCarthy[1] Creutzfeldt,[2] Bablik,[3] Warner,[4] Taussig,[5] Rhodes and Kuhn[6] and others. The addition of an arsenic compound to the liquid is another possible way of reducing attack on the metal, and has actually been employed in a special case,[7] but would not be without danger for general purposes. A third alternative worth considering is to give the articles electrochemical protection by making them the cathodes to a current supplied from an external source. It is doubtful whether this notion is really novel, since "cathodic cleaning" has long been employed as an alternative to pickling, and it is sometimes, although not always, conducted in acid solution. But no experiments seem to have been performed to decide how far cathodic treatment does protect the metal from dilute acid. Of course cathodic protection has long been employed in connection with boiler and condenser corrosion, and in such cases some data are available; but here the waters are not strongly acid.

Test of the Cathodic Protection Method

The authors recently had occasion to test the method in a case where it was desired to remove from iron thin oxide-films (of the thickness responsible for "temper-colors") without the smallest attack upon the metallic basis. Very dilute acid (N/100) will serve to remove these thin films quite quickly, yet even these strengths have an appreciable action on the metal. Attempts were, therefore, made to apply cathodic protection, and it is thought that the measurements carried out may be of sufficient general interest to warrant publication.

The iron used was electrolytic sheet, 0.3 mm. thick, kindly provided by Dr. W. H. Hatfield, and contained 0.03% carbon, 0.04% manganese, 0.02% phosphorus, 0.005% sulphur, a trace of silicon and no nickel or copper. Strips of this iron were ground with French emery No. 1 and heated in air by floating on a bath of molten lead-tin alloy until the (1st order) reddish-brown temper-color was produced. After cooling, the backs and edges were protected with clear "Belco" nitrocellulose varnish; part of the front surfaces were blocked out with the same varnish, an area of 3 sq. cms. being left exposed. Next the specimens were fixed vertically in an electrolytic vessel opposite a vertical platinum anode which extended to a slightly lower level than the iron. The iron and platinum were joined through suitable resistances and a milliammeter to storage batteries; the air was displaced by carbon dioxide, and after 15 minutes, N/100 sulphuric acid free from oxygen was introduced at the bottom; a large quantity of this acid, boiled free from oxygen, was preserved under a carbon dioxide atmosphere in a large reservoir. As soon as the acid touched the iron, current commenced to flow, the iron being the cathode. After one hour's treatment, the solution was syphoned off from the top, being replaced simultaneously by fresh (iron-free) acid, care being taken that the level was maintained constant. After a further period of 4 hours, the solution was again changed, and the soluble iron in the two portions determined separately by the colorimetric (thiocyanate) method; the results at different current densities and the corresponding results in the absence of applied current are shown in Table A. A few experiments with 10% acid—a strength often used in commercial pickling to remove thick scale—are included; these are somewhat less accurate owing to the tendency of the attack to spread below the varnish coat.

Table A—Soluble Iron Found in Liquid Drawn Off after 1 and 5 Hours from Specimens Heat-Tinted Reddish-Brown (First Order) and Immersed in Air-Free Sulphuric Acid; Expressed in Multiples of 10^{-5} Grams Ferric Oxide per Sq. Cm.

Cathodic Current Density Amps. per Sq. Cm.	N/100 Sulphuric Acid 1st Hour	N/100 Sulphuric Acid Next 4 Hours	10% Sulphuric Acid 1st Hour	10% Sulphuric Acid Next 4 Hours
Zero	9.7	45.5	38.0	168.0
0.0005	3.4	2.3	..	...
0.0010	3.2	1.7	5.8	4.2
0.0017	2.5	1.5	...	...
0.0023	1.6	1.1	4.8	5.8

In another series of experiments, the acid was replaced at the end of four periods of 15 minutes each; the iron present in the four portions is shown in Table B. In this series, specimens oxidized to give different colors were included. The tests also comprised iron rendered passive in chromate solution, and iron abraded, and merely exposed to air for the short period needed for the drying of the varnish; these unheated specimens had no visible oxide-film, although oxide, in amounts too small to give interference tints, was undoubtedly present. The curious fact that the second portion drawn from the specimens tinted greenish-blue at 0.0007 and 0.001 amps. contained more soluble iron than the first, was verified by repetition of these experiments.

In both sets of experiments some mixing occurred during the replacements of acid; nevertheless the quantity of iron left behind from the early periods cannot account for the whole of that found in the later portions of liquid syphoned off.

The numbers make it clear that even a very low cathodic current density enormously reduces corrosion of the metal, although a low current seems rather to favor the dissolution of the thicker oxide-films; possibly the inert ferric oxide is reduced to the rapidly soluble ferrous oxide; clearly if

Table B—Soluble Iron Found in the nth Portion of n/100 Sulphuric Acid Expressed in Multiples of 10^{-5} Grams Ferric Oxide per Sq. Cm.

Cathodic Current Density (Amps. per Sq. Cm.)	Zero				0.0003				0.0007				0.0010			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Iron tinted to second order greenish blue	6.0	5.8	4.2	2.8	10.0	4.0	1.6	0.7	5.5	5.8	3.3	1.1	5.1	8.1	3.3	1.6
Iron tinted to first order silver-blue	7.5	6.6	5.6	6.4	3.6	1.1	0.9	0.6	3.0	1.4	0.5	0.2	2.4	1.6	0.6	0.4
Iron tinted to first order reddish brown	8.0	5.1	4.3	4.2	3.4	1.1	0.4	0.3	2.8	0.7	0.3	0.3	2.4	0.9	0.4	0.2
Iron immersed 45.7 hours in n/10 potassium chromate	6.4	4.5	3.4	3.6	3.7	2.1	1.0	0.4	3.0	1.7	0.8	0.4	2.9	1.6	0.5	0.2
Iron ground and exposed to air 30–40 minutes	5.5	5.4	5.0	5.2	4.1	1.8	0.8	0.4	3.3	1.5	0.5	0.3	2.6	1.1	0.5	0.3

* Cambridge, England.

[1] *Ind. Eng. Chem.*, **20**, 582 (1928).
[2] *Korr. Met.*, **4**, 103 (1928).
[3] *Korr. Met.*, **4**, 179 (1928).
[4] *Trans. Amer. Electrochem. Soc.*, **55**, 287 (1929).
[5] *Arch. für Eisenhüttenwesen*, **3**, 253 (1929).
[6] *Ind. Eng. Chem.*, **21**, 1066 (1929).
[7] See A. S. Dwight, *Trans. Amer. Inst. of Min. & Met. Eng.*, **39**, 814 (1908).

the current is too high, direct reduction to the metallic state may modify the effect. But it is interesting to note that—whatever the preliminary treatment—the cathodic protection does not completely prevent the dissolution of metallic iron in the early stages. Protection comes in gradually with the time in a degree varying slightly with the current density. It is possible that the so-called cathodic protection in acid solution may depend partly on the fact that the current deposits the metal nearly as fast as the corrosion dissolves it; therefore it only becomes effective when the liquid layer next to the metal becomes enriched in iron ions and impoverished in hydrogen ions; no doubt it will also be favored, when a number of nuclei of electro-deposited iron have appeared on the surface. The quiet dissolution of iron oxide is likely to be more favorable to subsequent redeposition as metal than the dissolution of metallic iron, which involves stirring by hydrogen bubbles.

Conditions Determining the Resistance of Metals to Acid

It may be useful to summarize the various conditions which can produce immunity of metals towards acid. When a metal is placed in dilute sulphuric acid, it begins to pass into the ionic condition, turning out hydrogen ions, so that metallic ions accumulate in the adjacent liquid layer, and hydrogen, probably atomic, accumulates in the metal. This process may be brought to a stop in several ways:

(1) If the liquid layer becomes supersaturated with the metallic sulphate, further attack must then convert the metallic surface *in situ* into *solid* sulphate, which will not dissolve, and thus attack will die away. No doubt this explains the immunity of lead to sulphuric acid. But the sulphates of iron are too soluble to appear in the solid state, unless convection is diminished by screening, and the rate of production of the sulphate is increased by *anodic* treatment from an external source; under such conditions, the attack—very rapid at first—after a time slows down, and W. J. Müller[8] has identified crystalline ferrous sulphate on the metallic surface.

(2) If the accumulation of hydrogen and metallic ions reaches such a stage that the potential *metal/metallic ions* is balanced by the potential *hydrogen/hydrogen ions*, dissolution will cease. This explains why copper is almost undissolved by dilute sulphuric acid in the absence of oxygen; for here quite a small concentration of copper ions and an extremely small concentration of hydrogen will serve to bring about the state of balance. But with iron, which occupies quite a different position in the "potential series," the theoretical concentration of metallic ions and hydrogen for balance are fantastically large; in practice, the balance will never be arrived at owing to (*a*) the streaming away of hydrogen gas in bubble form (*b*) the diffusion of iron ions into the body of the liquid (aided no doubt by the stirring action of the bubbles). If, however, a *cathodic* current is applied, the ordered movement of cations towards the metal may oppose, and finally almost balance, the passage of metal into the ionic condition, while the increased hydrogen pressure within the metal will also oppose corrosion; this seems the best way to interpret cathodic protection.

(3) If an *oxidizing agent* is added, it will often stimulate the attack, at any rate when the oxide of the metal is quickly soluble in the acid; thus potassium dichromate renders possible the continued corrosion of copper by dilute sulphuric acid.[9] Many sesquioxides, however, are only slowly soluble in acids, and in such cases oxidizing agents may sometimes actually prevent attack by acids. The recent researches of Hedges[10] and of Benedicks and Sederholm[11] have indicated that the immunity of iron towards certain concentrations of nitric acid is due to the fact that iron oxide is produced more quickly than it is dissolved, and thus constitutes a protective film on the metal. The presence of chromium yields a specially protective oxide, and this increases the resistance to nitric acid, whilst reducing the resistance to hydrochloric acid.

(4) Certain colloidal and nitrogenous substances greatly reduce the attack of iron by non-oxidizing acids, as stated at the commencement of this paper. According to Chappell,[12] this is due to the fact that the substances obstruct the evolution of hydrogen gas by raising the over-voltage, but Warner[13] takes the view that in some cases they oppose the passage of iron into the ionic condition. In either case the replacement of hydrogen by iron is brought almost to a standstill, under conditions where otherwise it would continue apace.

Summary

In using sulphuric acid to remove oxide-films from iron, the attack on the metal may be enormously reduced by applying a small cathodic current, whilst the attack upon the oxide is not prevented, and in some cases somewhat stimulated. The degree of protection depends on the current density, and is least effective in the earliest stages; the rate of attack upon the iron falls off with the time.

A short discussion is appended of the conditions which produce immunity of metals from acids.

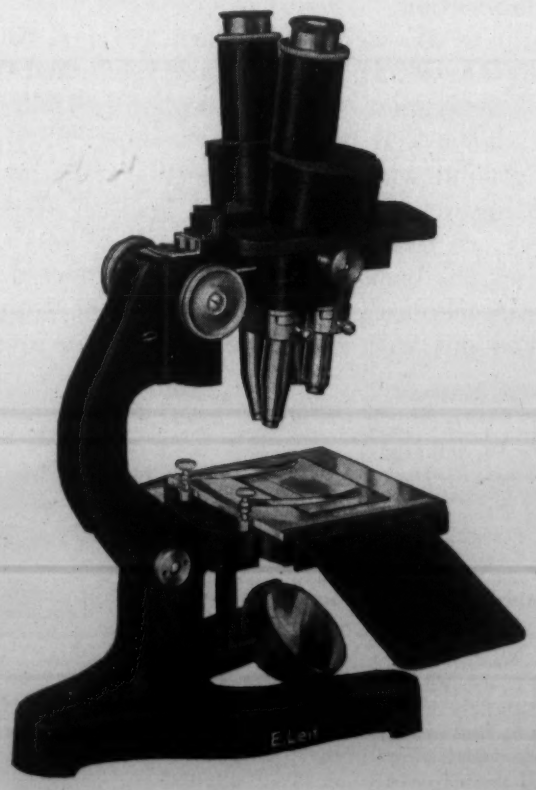
[8] *Zeitsch. Elektrochem.*, **34**, 577 (1928).
[9] See O. P. Watts and N. D. Whipple, *Trans. Amer. Electrochem. Soc.*, **32**, 268 (1917).
[10] *J. Chem. Soc.*, page 969 (1928).
[11] *Zeitsch. Phys. Chem.*, **138**, 123 (1928).
[12] *Ind. Eng. Chem.*, **20**, 587 (1928).
[13] *Trans. Amer. Electrochem. Soc.*, **55**, 287 (1929).

A New Metallurgical Microscope

E. Leitz, Inc., 60 East 10th Street, New York, have recently introduced a new microscopical construction known as The Leitz Wide Field Binocular Microscope with Automatic Multiple Objective Nosepiece.

The new instrument supplied with this Automatic Multiple Objective Nosepiece serves excellently in metallurgical laboratories for examination of metal surfaces, gross specimens, fractures, etc., under low and medium powers. The pronounced stereoscopic effect rendered by this Microscope is a distinct advantage. The addition of the Automatic Multiple Objective Nosepiece, contributes materially toward enhancing the usefulness of Wide Field Microscopes in industrial laboratories.

This instrument is described completely in their pamphlet No. 1169.



Correlated Abstract

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts reviewing the work recently reported pertaining to certain subjects. These reviews will take into consideration the work of a number of workers. The current literature will be covered in the Abstracts of Current Metallurgical Literature.

Corrosion and Its Prevention in the Oil Industry

Several papers delivered December 4 and 5, 1929, at the Chicago meeting of the American Petroleum Institute deal with this subject, which is of as much interest to metallurgists as to petroleum engineers.

The report of the committee on refinery and marine corrosion, including its sub-committees, presented by W. Samans (Atlantic Refining Company) (8 pages), emphasizes the importance of corrosion by high sulphur oils, though only a part of the sulphur compounds are corrosive. A 10,000 bbl. per day unit for distillation of crude, daily receives 24 tons of sulphur and a ton of chlorides in the crude. Under test in refluxers at 400° F. where there would be attack by sulphur but no condensation of HCl, the following losses in percent, were shown in 6 months: copper 11.3, zinc 1.8, mild steel 1.4, cobalt 0.8, nickel 0.7, wrought iron 0.6, tin 0.4, aluminum 0.2, cast iron 0.1, chromium none. Chromium iron and chromium nickel iron alloys are resistant to sulphur but not to HCl. Admiralty metal is used to combat HCl. Use of 3 to 25 lbs. ammonia per 1000 bbl. crude has increased the life of the parts subject to HCl attack to over a year. Caustic is less than half as effective.

To combat sulphur corrosion, hydrated lime is used, about ¼ lb. of lime per bbl. of crude (with 1.62% S) which increases the life of the hottest tubes in a tube still to more than a year. Repairs per million bbls. crude are cut from $11,000 to $2,000. The yearly saving over the cost of the lime on a 10,000 bbl. per day still is estimated at $24,000.

Corrosion in pressure stills is dealt with in Samans' report, and also in a separate paper to which reference will be made later.

As the cracking processes may operate at 600–1000° F. and 800 to 2000 lbs./in.², alloys are required that are strong under those conditions as well as corrosion-resistant. Freedom from embrittlement in use and from initial flaws is also required. Electrical resistance methods analogous to that of the rail detector for transverse fissures are being sought for longitudinal flaws in still tubes, and X-ray metallography is being applied to some extent to tube header and valve castings.

High chromium alloys are useful in meeting the conditions imposed. Chromium plating, even at a cost for preparing the surface and plating it of $5.00 per sq. ft. is being tried, some operators considering the results encouraging. In the paper, "Pressure Still Corrosion," by J. K. Whitman and J. K. Roberts (Standard Oil Company) (5 pages), the high chromium alloys are approved for those applications where the safe life of the part is short when made from other materials, but chromium plating is classed as disappointing because of pinholes. Imperfections in calorized coatings have made them generally discredited for this purpose, though some recent installations are classed as "reasonably satisfactory." Cement linings for unfired parts of the equipment, properly reinforced, are classed as economical and satisfactory.

The 16–18% chromium alloys without nickel are considered unsatisfactory as tube material because of embrittlement at high temperatures, but satisfactory when they contain 8% nickel also, though on account of cost, their use is limited to the worst conditions. The 12–14% Cr alloy is less resistant than that with higher Cr content, but is claimed to be free from embrittlement. Perhaps the most promising from the economic point of view, is an alloy with 4–6% Cr, costing only twice as much as mild steel, but with 4 to 10 times its corrosion resistance.

The use of hydrated lime in the feed to pressure stills has reduced the corrosion rate from between 0.1 and 0.2″ per year to between 0.01″ or less, and 0.03″. The sulphur that is so combined that it will produce H_2S determines the amount of lime needed. The corrosiveness is not a direct function of the total sulphur. A mixture of stocks may be less corrosive than would be calculated from the data on the individual stocks.

Two-thirds of the lime added appears in the tar, and may notably diminish the value of the tar. Caustic soda causes formation of a dense coke hard to remove. Treatment with lime reduces the H_2S and thus protects the whole system while the use of a resistant alloy protects that part only.

Whitman and Roberts state that the corrosion in cracking plants is due to H_2S. Another paper, "Cause of Corrosion in Cracking Plants," by E. Retilliau and F. R. Lang (Shell Petroleum Corporation) (6 pages), reports experiments indicating that the apparent attack by H_2S or by organic sulphides is in reality due to their decomposition, and direct attack upon the iron by the free sulphur. Study of scale from commercial cracking units also indicated that the corrosion products are primarily iron sulphide and that HCl corrosion plays no part under the conditions met.

Returning to Samans' committee report, condenser corrosion is discussed. External corrosion from cooling water is less with submerged condensers than with spray cooling because of aeration in the latter. Internal corrosion is not due, at these temperatures, to sulphur but to HCl. NaOH or NH_4OH neutralization may or may not be economically justifiable.

Corrosion of tanks and pipe lines is also discussed in the report. Tests of 100 different paints show none satisfactory as inside protection in tanks. Replacement of roof and upper ring after 3 to 6 years and the use of heavy plate are considered better than protection. The report states that for sour crudes or distillates, either copper bearing steel or Armco iron is preferable to plain steel.

Under corrosion of minor equipment it is stated that it is hoped that centrifugal cast iron pipe for gas lines will show better life than sand cast iron. In acid sludge disposal high chromium steel tubes are competing with red brass. Seamless pipe and tubing for hot oil and gas and for high pressure cold gas lines finds favor over the lap-welded product.

Corrosion on tankers is a problem hard to study, since a ship's hull made up of many different alloys is subject to electrolytic attack, and gives erroneous experimental results. One company is towing separate samples behind the tanker on her regular trips.

A paper on "Aluminum and Its Alloys as Corrosion-Resistant Materials in the Oil Industry," by S. Gill (Gulf Pipe Line Company) (8 pages), points out that since much corrosion in the oil industry is due to H_2S, to which aluminum is highly resistant, aluminum and its alloys are suited for materials of construction in some phases of the oil industry. Chlorides, oxygen concentration cells and contact with iron sulphide all cause corrosion of aluminum alloys, though oil field brines are not as corrosive as might be expected.

On account of weakness at high temperatures of aluminum as well as the instability of heat-treated aluminum at temperatures above that which gives the optimum strength on heat-treatment, the aluminum alloys are only to be considered for service below 350° F. and normally below 250° F.

In oil well equipment, corrosion by brines is severe and aluminum had only one half the life of ordinary steel pipe.

Lease tanks on a high sulphur oil which cut through steel bottoms in 5 or 6 months and side walls in 12 to 14 months were made of an aluminum alloy with 1.25% Mn (bolts, etc., being duralumin). The bottom stood up for 18 months and the side walls were merely etched, not really corroded. The cost is only twice that of a steel tank. Further test is being made.

Wooden tank decks are being made with duralumin nails and sheathed with light gage aluminum with good results on high sulphur crudes.

Coating the tops and the outside of storage tanks with aluminum foil say 0.003″ thick, applied over an adhesive of proper tackiness, gives a highly reflecting surface and reduces vapor

space temperatures, and hence evaporation losses, even more than aluminum paint does. The durability should be better than that of aluminum paint. Tank cars are similarly coated. Use of foil on tank interiors to prevent corrosion depends on finding a suitable oilproof adhesive. It is thought that such adhesives are now available, and experiments are under way on tank linings.

Foil coatings on pipe lines, to protect the present coating materials from soil stress effects and to prevent or delay their breakdown, are being extensively experimented with, but Gill classes this as still a pure experiment.

G. N. Scott (A. P. I. Research Associate at the Bureau of Standards) reported on "The Field Inspection of Protective Coatings Applied to Oil and Gas Lines." (10 pages.) Thin spots in bitumen coatings, whether initially present or caused by soil stresses, are to be viewed with suspicion, as these materials do not remain completely impervious to moisture.

Soils that are corrosive to bare pipe also corrode coated pipe, acting through the thin spots in the coatings. Soil quality is the most important factor. The breakdown of almost all coatings is disconcertingly rapid. Pitting may be markedly accelerated over that shown by bare pipe, if an imperfect, partly disrupted coating is present. A "protective coating" unless it is, and remains, wholly intact, may be no real protection. Felt wrappings for reinforcement of the coatings delay breakdown of the coating and attack of the pipe. Every additional ply affords some additional delay. The value of such wrapping is not in resisting infiltration of corrosive agents, but in helping the coating to resist mechanical distortion. Addition of sheet iron, wood veneer or aluminum foil wrappings, cemented to the coating or merely wrapped without cementing, is being tried on a considerable scale but these have not been in service long enough to establish what advantage, if any, lies in the practice.

It is interesting to note the conclusion that "it is not feasible to determine from field inspection what prolongation of pipe life may be expected from any particular treatment." Five-hundred field inspections, made in 1929, considered in the paper, together with many previous ones, make it clear that if the desired information on economic value of protective coatings is to be obtained, it must be done by special, suitably controlled field experiments, not by observation of commercial installations in which many important variables that need to be known are unknown.—H. W. Gillett.

Calendar of Meetings

Franklin Institute, at the Institute, Philadelphia, Pa., Feb. 19, Feb. 27, March 13, March 16.

American Ceramic Society, Royal York Hotel, Toronto, Canada, Feb. 16–21.

American Society for Steel Treating, New York, N. Y., Feb. 14–15.

American Institute of Mining & Metallurgical Engineers, Engineering Society's Building, New York, N. Y., Feb. 17–20.

Canadian Institute of Mining & Metallurgy, Royal York Hotel, Toronto, Canada, March 5–7.

American Mining Congress Southern Division, Little Rock, Ark., March 10–12.

Symposium on Automotive Materials, (A. S. T. M.) Book-Cadillac Hotel, Detroit, Mich., March 19.

American Society of Mechanical Engrs., New York, N. Y., April 5.

All American Aircraft Show, Detroit, Mich., April 5–13.

American Chemical Society, Atlanta, Georgia, April 7–11.

National Metal Trades Association, Hotel Astor, New York, N. Y., April 16–17.

American Welding Society, New York, N. Y., April 23–25.

National Academy of Sciences, Washington, D. C., April 28–30.

American Iron & Steel Institute, Hotel Commodore, New York, N. Y., May 9.

American Foundrymen's Association, Cleveland, Ohio, May 12–17.

American Society of Mechanical Engineers, Fourth National Aeronautic Meeting, Dayton, Ohio, May 19–22.

American Electrochemical Society, St. Louis, Mo., May 29–31.

American Institute of Chemical Engineers, Book-Cadillac Hotel, Detroit, Mich., June 4–6.

Association of Iron & Steel Electrical Engineers, Buffalo, N. Y., June 16–20.

World Power Conference, Berlin, Germany, June 16–25.

American Society for Testing Materials, Haddon Hall, Atlantic City, N. J., June 23–27.

Society for the Promotion of Engineering, Montreal, Canada, June 26–28.

National Metal Congress and Exposition, Hotel Stevens, Chicago, Ill., Sept. 22–27.

American Gas Association, Atlantic City, N. J., Oct. 13–17.

Association for the Advancement of Science, Cleveland, Ohio, Dec. 29–Jan. 31, 1931.

At the Annual Meeting of American Engineering Council held at the Mayflower Hotel, Washington, D. C., January 10, **Mr. Carl E. Grunsky,** was elected President for the 2 years, 1930 and 1931. Mr. Grunsky is the Senior Member of the C. E. Grunsky Co., San Francisco. He is President of the California Academy of Sciences and Past President of the American Society of Civil Engineers.

The Mason Regulator Co., of Boston announces the appointment of the O'Brien Equipment Co., St. Louis, as exclusive distributors in the Missouri territory.

F. M. Hesse has been appointed secretary of the National Steel Corporation formed by the merger of the Weirton Steel Co., Great Lakes Steel Co. and the blast furnace subsidiaries of the M. A. Hanna Co.

$25,000,000 Tin Smelter Merger

Recent advices from London report a provisional agreement for a merger of four of the largest and most important tin smelting companies of the world. About half of the world's tin supply in control of the Anglo-Oriental tin interests, the Patino interests who lead in Bolivian production and prominent members of the newly formed Tin Producers' Association is affected.

The announcement of the provisional agreement following so quickly the action of the Association in calling for production restrictions in the Far Eastern fields is expected to have a far-reaching influence upon stabilizing the industry.

The new company comprising the Cornish Tin Smelting Company, the Eastern Tin Smelting Company, the Penpoll Tin Smelting Company and Williams, Harvey & Co., will be by far the largest tin smelting organization in the world.

Under the provisional plan a holding company will be formed with an authorized capital of £5,000,000, £2,000,000 of which will be in 7% noncumulative £1 preference shares and £2,000,000 in £1 ordinary shares, £3,000,000 of which will be outstanding upon consummation of the plan, which calls for the exchange of the shares of the holding company for the shares of the four companies in the merger.

A. S. M. E. Fiftieth Anniversary

The American Society of Mechanical Engineers will celebrate its fiftieth anniversary on April 5, 7, 8 and 9, 1930. The celebration will take place in New York City, the headquarters of the Society, in Hoboken, N. J., its birthplace, and in Washington, D. C., a place fittingly in accord with the national and international character of the convocation. The world's leading scientific and engineering societies and educational institutions have been invited to send two delegates each to the celebration.

The celebration will review the past fifty years of engineering achievements, bringing together the world's outstanding men in engineering. A series of sixteen papers will be presented, each summarizing and evaluating the contributions of engineering to the cultural, social, economic and political life and also visualizing the future of the engineer's place in the promotion of the common welfare in one of the sixteen selected geographical divisions of the world.

The events of the celebration in New York City will take place at the United Engineering Societies Building in the morning of April 5, and at Stevens Institute in Hoboken, in the afternoon. The papers will be presented in the U. S. Chamber of Commerce Building in the National Council Chamber on April 7 and 8.

Howard C. Cross, formerly with the Bureau of Standards at Washington, is now research fellow for the Federal-Mogul Corp., at the Battelle Memorial Institute at Columbus, Ohio.

P. E. Peterson, formerly with the Ford Motor Co., is now associated with the Commercial Steel Treating Corp.

Critical Abstract

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts of a critical nature on articles of special importance. The current literature will be covered in the Abstracts of Current Metallurgical Literature.

Interstate Commerce Commission Reports on Rail Failures

Reports of the Director of the Bureau of Safety on investigations of accidents (a) on the Atchison, Topeka & Santa Fe near Yampai, Arizona, March 13, 1928, report dated March 25, 1929, (b) on the Missouri Pacific at West Junction, Kansas, June 25, 1928, report dated July 18, 1929. For sale by Supt. of Documents, Washington, D. C.—10¢ and 15¢ respectively.

These reports, signed by W. P. Borland, Director, and prepared by J. E. Howard, engineer-physicist, deal with two types of rail failures, describing the particular failures causing the accidents, but also discussing many generalities on the types of failures represented.

The Yampai rail failure is ascribed to a fracture of the base due to surface seams. The base fracture was covered by splice plates and hidden from view. The rail, so weakened, broke completely under a train. General discussion deals with crescent-shaped base fractures due to longitudinal seams, not apparent under the mill scale but revealable by hot acid etching. Several other rails from different mills were etched for comparison. Some base seaminess was found in all, a medium manganese "A" rail showing especially marked seams. The report states, "Cases have been presented in which base seaminess was so pronounced that fragments could be knocked off with a sledge almost anywhere. On the other hand, crescent breaks have been started by seaminess of such limited extent that only complete and absolute elimination of the seams would seem effectual against ultimate rupture from that cause." "Influences which lead to the formation of surface seaminess appear to cause different results on different occasions. Some rails are nearly free from seaminess, whereas others are very much affected, too seamy to justify putting them into the track."

The report thus indicates that this failure was due to seams, and that there is some limit of seaminess that would justify rejection of the rail, the seaminess being invisible without pickling. No information or suggestion is given in the report to indicate what inspection methods should be utilized to prevent installation of too seamy rails, nor what the limit of seaminess should be. The reader gets the impression that if seamy rails are installed, and cause failures, "it's just too bad." The report says that there is a danger zone in the area hidden from inspection by splice plates, but does not suggest anything to be done about it.

Dr. Howard takes a crack at the making of tensile and hardness tests, and determination of chemical analysis and microstructure, as "a great waste of effort" and having no specific relation to the cause of rupture when failure is obviously due to seaminess. The abstractor would think that in view of the admitted haziness as to the permissible limit of seaminess, definite proof that the rail was up to standard, aside from its seaminess, would give better proof that seams alone were responsible, and not some other contributing factor as well, and feels that in so important a matter as a derailment that cost the lives of the engineman and firemen, such analyses and tests, which the report does not give on the broken rail, might well have been made.

The other report, on the West Junction failure, shows the failure to have been due to transverse fissures in a rail which, at the time of the accident, broke into 10 fragments. The rail was a Colorado Fuel and Iron Company rolling of 1916 which had been in service 11 years. No analyses, physical tests or microscopic examinations of the rail are reported.

One of the longer fragments of the rail was examined in the laboratory of the Sperry Development Company by the "detector," and other transverse fissures were located, their position and something as to their relative size being predicted. One of these indicated fissures was brought to the surface by peening; others were found at the indicated locations by cutting up the rail.

The report then eulogizes the Sperry detector, and discusses the transverse fissure situation. As usual, Dr. Howard minimizes the possible effect of pre-existing nuclei for fissures, commenting that "if the nucleus is small, there would seem little difference in the initial effort necessary to enlarge the fissure over the effort required to originate it," a comment with which those acquainted with the concentration of stress at a crack may not be inclined to agree. He says that longitudinal streaks undoubtedly lead to the formation of compound transverse fissures, but further data are needed to demonstrate the influence of shrinkage cracks. With this again, those who are acquainted with the vastly greater influence of a transverse crack than of a longitudinal one in an endurance test, are likely to be unconvinced.

Yet Dr. Howard leans toward the idea that internal strains (which he ascribes more to wheel loads than to cooling stresses) on the verge of rupture, may be opened up into cracks by wheel loads or by rapid solution of overstrained steel in pickling to reveal shrinkage cracks. If such strains are to be considered as nuclei for fissures, the next step from a strain being a crack, why is not a pre-existing crack also to be considered a nucleus?

Dr. Howard reiterates his previously expressed belief that "theoretically and practically all rails are exposed to conditions that culminate in the destruction of the metal. . . a definitely known margin of safety does not exist in rails." "Since it is impossible to avoid these intense pressures, the practical question is what grade of steel will best endure them."

He says "Eighteen years have elapsed since this insidious type of fracture was brought to general notice, and yet no adequate, comprehensive research has been inaugurated toward the amelioration of conditions." "The construction of a special experimental track, special equipment and special heats of steel are unnecessary, and would be well calculated to indefinitely defer an answer."

Is the search for a grade of steel to withstand the pressures then to be confined to regular production heats of steel?

Dr. Howard admits that the detection of transverse fissures, for which conditions are more favorable than ever before, since the Sperry detector is available, is a different problem from their elimination, but feels that with this "divining rod" available, conditions are ripe for a joint comprehensive inquiry.

The report amounts to an almost unqualified eulogy of the Sperry detector, and the reader would be likely to get the idea that all the "bugs" are out of the apparatus, not only as a laboratory device, but also as a practical means of track inspection. While it is apparently well on the way toward this desirable conclusion, the public may be led to expect too much from the present-day track detector.

The report deals with many aspects of the transverse fissure problem, the actual failure occupying but a small part of the report. Very little indication is given as to how the comprehensive joint inquiry for which Dr. Howard pleads should be conducted.—H. W. GILLETT.

Start in Spring on Study of Oil Pipe Line Coatings

Manufacturers of protective coating for pipe lines and interested oil men have been invited by Dr. George K. Burgess, Director of the Bureau of Standards, U. S. Department of Commerce, to suggest types of coatings for study in a cooperative investigation to be made cooperatively by the American Petroleum Institute, the bureau and manufacturers.

The study, which seeks to determine engineering principles upon which selection of protection for pipe lines should be based, will cover approximately 10 types or classes of coatings applied to working oil lines in destructive soil. Those interested have been asked to file, not later than January 30, their suggestions as to one or more types they believe should be studied, in order that the tests may be started in the spring.

Abstracts of Current Metallurgical Literature

In this section, abstracts of metallurgical articles in various publications will appear. These abstracts are not critical, but merely review developments as they are recorded. Every effort will be made to report on all articles as soon as possible.

PROPERTIES OF METALS

Melting Point of Chromium. C. J. Sunthells & S. V. Williams. *Electrician*, Nov. 29, 1929, page 673.

The melting point is determined as 1920° C. WHB

Abstracts of Articles on Fatigue of Metals under Repeated Stress, appearing in the *Technical Press* from July 1, 1928 to June 30, 1929. Prepared by the A. S. T. M. Research Committee on Fatigue of Metals. Published by the American Society for Testing Materials, Philadelphia, 27 pages.

This pamphlet gives abstracts of 53 articles on endurance. The abstracts are full enough so that they give a pretty good idea of the original articles. While the committee states that not all articles in the field, especially foreign ones, have been covered, yet the collection is complete enough to be useful. Those interested in fatigue of metals will find the collection convenient. Such collections will probably be issued annually. HWG

Remarks on the Electron Theory of Ferro-magnetism and Electric Conductivity. (Bemerkungen zur Elektronentheorie des Ferromagnetismus und die Elektrische Leitfähigkeit.) F. Bloch. *Zeitschrift für Physik*, 1929, Vol. 57, No. 7–8, pages 545–555.

The possibility of basing ferro-magnetism on the conduction-electrons is discussed. A discussion of the center of gravity of the energy and of the multiplicity of the existing term-systems shows that the occurrence of ferro-magnetism is bound up with the zero point energy. Ha

Hardness and Grain Size. (Härte und Korngrösse.) K. Honda. *Metallwirtschaft*, Oct. 1929, pages 985–986.

The well-known fact that hardness of metals increases with the decrease of their grain size is discussed and the investigations of Yamaguchi along these lines are given. The hypothesis of amorphous metal cement and the slip interference theory are considered and the latter is mathematically presented. EF

The Physical Properties of Cast Metals Including Iron in Relation to the Casting Method. (Die Festigkeitseigenschaften von Metallguss einschliesslich Eisen in Abhängigkeit von der Giessweise.) G. Schreiber & H. Menking. *Zeitschrift für Metallkunde*, Sept. 1929, pages 297–302.

The authors report on their comprehensive investigations of cast metals, which were carried out with the object of disclosing the causes which are responsible for the differences of strength values sometimes amounting to 200% of the lowest value. The well-illustrated paper which was presented before the "Deutsche Gesellschaft für Metallkunde," May 1929, gives the pattern of the model used in the experiments. EF

On Shrinkage of Metals. (Einges über die Schwindung der Metalle.) F. Sauerwald. *Zeitschrift für Metallkunde*, Sept. 1929, pages 293–296.

Attention is called to the fact that shrinkage value depends on physical constants on one hand and on conditions prevailing during casting on the other. Factors which are connected with the conditions in the foundry are given and an experimental arrangement is illustrated which permits determining these influencing factors separately. The author and his collaborators proved that gases exert an influence upon the shrinking process, which phenomenon was investigated in Cu-Sn alloys. EF

PROPERTIES OF NON-FERROUS ALLOYS

Light Weight Can Be Obtained with Aluminum Alloys. A. H. Woollen. *Electric Journal*, Oct. 1929, pages 468–470.

Strong Al alloys have made possible light-weight rolling stock with faster schedules, quicker acceleration and deceleration and greater comfort for passengers. The initial cost of cars is higher, but operating, and probably maintenance costs are lower. WHB

Everdur and Tempaloy. W. H. Bassett. *American Metal Market*, Oct. 23, 1929, page 3.

Everdur and tempaloy are alloys of copper with silicon and other metals and have approximately the physical properties of steel. Everdur made for casting may be forged and rolled hot, but will stand little cold working. Wrought everdur is hardened by drawing or rolling, is resistant to acid and alkaline corrosion. Everdur for casting contains: 94.8% copper, 4% silicon and 1.2% manganese, while for wrought forms, it contains 96.0% copper, 3% silicon and 1.0% manganese. WHB

Service Characteristics of Light Alloys. E. H. Dix. *Journal Society Automotive Engineers*, Nov. 1929, pages 463–468.

Cleveland Aeronautic Meeting paper. Includes discussion. Physical properties of aluminum and magnesium base alloys, heat treatment and aging effects at room as well as at higher temperatures are discussed in detail. The several types of corrosion are considered and means to protect the metal are mentioned. Protection by coating with pure aluminum or by paints and oxide films are described. GN

Alloys. (Legierungen.) E. R Thews. *Giesseizeitung*, Aug. 15, 1929, pages 450–455.

The article summarizes composition, properties and application of a large number of alloys, especially aluminum, light metals, brass and bronze alloys. GN

Properties of Locomotive Firebox Stays and Plates. O. F. Hudson, T. M. Herbert, F. E. Ball & E. H. Bucknall. *Paper before Institute of Metals*, Sept 1929, 80 pages.

A comprehensive report has recently been published on the properties of locomotive firebox stays and plates. The paper summarizes some results of metallurgical interest arising out of a research which the British Non-Ferrous Metals Research Association is carrying out for the British Railways. The first part of the paper is devoted to a consideration of the conditions existing in a locomotive firebox, and gives very briefly the principal results of the investigation into the causes of the wastage of stayheads in service. The main results obtained in the determination of the composition of firebox gases and temperature of stayheads are indicated. While wastage is primarily dependent on oxidation of copper, the severer forms are caused by the action of water leaking between stays and plate, this leakage water bringing about the loosening of the hard adherent oxide scale normally formed on arsenical copper in a firebox, and leading to its detachment and the exposure of fresh copper surfaces to oxidation. The conclusion is arrived at that leakage results from the plastic deformation of copper under the influence of thermal stresses, which leads to loosening of the fit of the stays screwed into the copper plate. Part II of the paper gives the results of an investigation of the oxidation of arsenical copper in firebox atmospheres, the properties of the oxide scale formed, and the action of leakage liquid. The rate of oxidation of arsenical copper in various atmospheres has been determined within the range of 260–600° C. The presence of small proportions of chlorine as hydrochloric acid gas causes a very great increase in the amount of oxidation in air and other atmospheres. There was no evidence that the presence of arsenic in the copper had any influence on the rate of oxidation. The conditions necessary to the formation of the dense, hard and firmly adherent oxide, which is characteristic of the scale formed on copper in a locomotive firebox, have also been studied, as well as those necessary to bring about loosening of the scale under the action of leakage water. Part II of the paper also contains the preliminary results of a study of the softening and elastic properties of cold worked copper containing small percentages of other elements. This emphasizes the importance of a more thorough consideration of the mechanical and thermal properties of locomotive firebox materials, and already indicates the possibility of selecting improved materials, which should greatly reduce wastage of stayheads. The investigation on the softening and elastic properties of copper is still in progress, but the results are given of a wide survey of the influence of other elements on the temperature of softening of copper in different degrees of cold-work. Tensile tests which have been made on a large number of these materials have included determinations of the elastic limit (limit of proportionality) at room temperature, and also in some cases at a temperature of 300° C. The object of these tests is to obtain, by alloying and suitable mechanical and thermal treatment, copper, otherwise suitable for firebox purposes, which will have and retain at service temperature a reasonably high elastic limit, say, of the order of 5 tons/in.^{2} Results have shown that there is a reasonable prospect of achieving this object, one of the most promising alloy additions being silver, of which as small a quantity as 0.05% appears to be sufficient. AEH

Properties and Use of Electron Metal. (Eigenschaften und Verwendungszwecke des Elektronmetalle.) G. Schneider. *Metallwirtschaft*, Sept. 27, 1929, pages 948–952.

Values of 11 most important physical properties of structural Mg-alloys in Germany and their manifold commercial applications are given. EF

The Effect of Constituents in the Structure of Brass and Their Influence upon Properties and Resistance to Deformation. (Die Wirkung des Gefügeaufbaus von Messing auf die Eigenschaften und die Verformbarkeit.) R. Schulze. *Dingler's Polytechnisches Journal*, Sept. 1929, pages 173–176.

The author considers the properties of the α and β phase in brass, the influence of type and amount of deformation, importance of heat treatment, corrosion resistance of α and β brass and commercial types of brass. EF

The Magnetic Properties of Isolated Ferro-Magnetic Atoms. F. W. Constant. *Physical Review*, Oct. 15, 1929, pages 1217–1224.

In order to obtain a better knowledge of the elementary atomic magnet, its behavior when surrounded by non-magnetic atoms rather than by other magnetic ones has been studied. For this purpose alloys of 90 and 95% platinum with the remainder cobalt and nickel, respectively, have been investigated. Only the cobalt alloys were found magnetic. The magnetic moment per cobalt atom being greater than for pure cobalt, the platinum may contribute to the magnetism.

Silver and Silver Alloys. (Silber und Silberleigierungen.) L. Sterner-Rainer. *Metallwirtschaft*, Aug. 23, 1929, page 824.

Based on experiences and investigations over a period of years, the author summarizes the knowledge necessary for the manufacturer concerning the metallography, chemical and physical properties of Ag and its alloys. The new alloys using Cd, Zn, Mn, Al and Sn instead of Cu are taken into consideration. The most important Ag-Cu alloys with 950/50, 900/100, 850/150, 800/200 and 720/280 are considered. The mechanical properties varying with stress are given for rolled sheets and drawn wires. Alloyed Sn induces high elasticity and elongation. In spite of an existing solid solution up to 20% Mn, the mechanical properties of alloys exceeding 0.5% Mn are unsuitable probably due to oxidation during casting. Small additions of Ni are recommended if, at the same time, Cu is present. 0.5% Al produce in the 800 Ag-Cu alloy an increase of elongation, but 3% of Al is the maximum. Ag-Cu-Cd alloys are unimportant according to the author. Small additions of Si influence the elongation. In solders Cd and Zn are employed, lowering the melting point. The addition of Si-bronze leads to Ag-Cu-Sn-Si alloys of high ductility but calls for special attention during annealing and tempering. If phosphorous copper is used for deoxidation, an excess should be avoided since the phosphides of Ag and Cu are rapidly tarnished. EF

Gold Alloys. (Die Goldlegierungen.) L. Sterner-Rainer. *Metallwirtschaft*, Aug 30, 1929, page 847.

Manufacture, melting points, metallography and physical properties of a large number of gold-alloys, preferably of commercial gold contents, are given. The formation of the compound AuCu must be avoided by quenching the specimens after casting or homogenizing at 600° C. On slow cooling AuCu is formed below 367° rendering the alloy brittle. The gold solders with additions of Zn and Cd are of particular importance. The author gives a review of the influence of Ag, Cu, Zn and Cd added to solders. In melting scrap and chips, Pb should be kept out since traces induce brittleness due to the compound Au_2Pb. Nowadays, white gold containing additions of Pd, Ni and Zn are very much favored. The initial difficulties encountered during manufacture are overcome. The properties can furthermore be influenced by additions of Mn, Sn and Al, while Pb, Bi and Sb spoil every gold alloy. EF

Contribution to the Knowledge of the Elastic Properties of Light Metals. (Beitrag zur Erkenntniss der elastischen Eigenschaften der Leichtmetalle.) H. Sieglerschmidt. *Metallwirtschaft*, Aug. 30, 1929, pages 843–846.

On special request, the Staatliche Materialprüfungsamt carried out investigations with the light alloys Duralumin, Lautal and Elektron in form of rods destined for manufacture of beams. The following results reproduced in 6 diagrams, were determined: tensile strength, elastic elongation, total permanent set after release of load. Each elongation ratio (reciprocal of modulus of elasticity), elastic reduction of area, total permanent reduction of area, Poissons ratio and cubic compressibility. The value of the Bach elongation ratio, the ratio of reduction area, the cubic compressibility and Poisson's ratio have been determined in the age-hardened, annealed and worked state. They differ only in Duraluminum and Lautal for the annealed and stressed state after two days by a few percent, but change with time. The influence of time had a pronounced influence on the magnitude and sign of remaining deformations due to low stresses. It is apparently necessary to store these alloys for weeks after working until a stable state is attained. The elastic and plastic deformations after elongating 0.2% of the measured length were changed due to internal stresses. Reduction of area was generally affected more than elongation. EF

PROPERTIES OF FERROUS ALLOYS

Iron-Silicon-Carbon Alloys. T. D. YENSEN. *Electrician*, Nov. 8, 1929, pages 556–559. *Paper before Iron and Steel Institute.*

Constitutional diagrams and magnetic properties and the effects of various heat treatments upon these alloys are discussed. No fundamental contradictions have been noted between the constitutional diagrams evolved and the experimental data. Some interpretations have been made without direct confirmation, but these have been indicated by dot-dash lines. The diagrams permit explanations of various magnetic phenomena exhibited by iron and iron-silicon alloys, both after slow and after rapid cooling. Magnetic testing is evidently much more sensitive in detecting small quantities of certain impurities, like carbon, and the form in which they exist than is either metallographic or ordinary chemical analysis. WHB

Determination of Specific Volume of Iron, Nickel and Iron Alloys in Liquid State. (Bestämning av specifica volymer for järn, nickel och järnlegeringar i smält tillständ.) C. BENEDICKS, N. ERICSON & G. ERICSON. *Jernkontorets Annaler*, Sept. 1929, pages 423–490.

A new method, developed by C. Benedicks was applied to study the density of iron and iron alloys at higher temperatures. The test method, described in detail, applied to the measurement of density, is a differential method. The specific volume of iron-carbon alloys increases with rising carbon content at constant temperature. Up to 0.4% carbon the curve rises faster, thereafter more slowly to 2.5% carbon, and then again rises faster up to 4.2% carbon. In the range investigated the slope of the curve of density corresponds to the liquidus curve of the iron–carbon system. The results confirm the known principle that the specific volume does not follow the mixing rule. Similar results were obtained in determining the specific volume of iron-nickel alloys. The specific volume is greater than it should be according to the mixing rule. The curve shows a maximum at 35% nickel. (Fe_2Ni contains 34.5% Nickel) Alloys up to this concentration are characterized by a negative coefficient of temperature, thereover the coefficient is positive. Iron alloys containing aluminum (carbon), chromium, manganese (nickel), phosphorus, silicon, tungsten show specific volumes, varying with the alloying element. The slope in the curves generally corresponds to the concentration. Specific volume decreases in the following order: carbon, aluminum, silicon, phosphorus, chromium, manganese. Carbon increases specific volume of iron most, manganese, less. Nickel and tungsten more so decrease specific volume. The changes of specific volume in liquid state are in satisfactory accordance with those in solid state. GN

High Elastic Limit Structural Steels. J. A. JONES. *Paper before Iron and Steel Institute*, Sept. 1929, 14 pages.

The author has investigated the effect of carbon, manganese, silicon and nickel on the properties of structural steels in plate and flat bar form, and draws the general conclusion that the best tensile properties are those contained in 0.3% carbon with about 1.3% manganese and 0.9% silicon. A small amount of nickel increases the ductility of low carbon steels but at least 3% is required in producing high elastic limit steel. AEH

The Hardness of Vacuum-Annealed Crystals of Iron. HUGH O'NEILL. *Paper before Iron and Steel Institute*, Sept. 1929, 27 pages.

The author has investigated the relationship between Brinell Hardness and Grain-Size of iron and finds that the hardness of normalized iron is lowered considerably by vacuum annealing. Tests showed that the "ultimate Brinell number" (i. e. area of impression equals diameter of ball) was independent of the grain size, within the limits of experimental error. At low testing pressures the fine grained re-crystallized material was softer than the coarse re-crystallized metal. Scratch tests proved, however, that different direction on the crystal faces had distinctly different scratch hardness values. Attention is drawn to the general relationship between hardness and electrical resistivity. AEH

Properties of Cast Iron of Interest to the Metallurgist, Founder and Engineer. By the Sub-Committee in Research of the Committee on Gray Cast Iron. *Preprint* 29-17, *American Foundrymen's Association*, pages 331–342.

The report outlines in 3 main groups causative, formative and effective properties of cast iron. The presented list is reasonably complete and is suited to develop a sense of appreciation for the differences in different grades of cast iron. GN

The Influence of Segregation of Graphite on the Solubility in Acids of some Cast Irons. (Der Einfluss der Graphitausscheidung auf die Säurelöslichkeit Verschiedener Gusseisensorten.) P. BARDENHAUER & K. L. ZEYEN. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 15 (Report 132), pages 247–254.

Cast iron is affected increasingly by 1 n. HCl, H_2SO_4 and acetic acid the more finely distributed the graphite crystals. The viewpoint often to be found in the literature that a rough graphite distribution is followed by an increased high acid solubility cannot be sustained. GN

On the Binary Systems Iron–Boron, Iron–Beryllium and a Contribution to the Knowledge of the System Iron–Aluminum. (Ueber die Zweistoffsysteme Eisen-Bor, und Eisen-Beryllium mit einem Betrag zur Kenntnis des Zweistoffsystems Eisen-Aluminum.) F. WEVER & A. MUELLER. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 12 (Report 129), pages 193–223.

The equilibrium system iron–boron was examined by thermal, microscopic and X-ray analysis. The system belongs to the group of binary iron systems with a narrowed area of gamma phase. The discrepancies with the diagrams of previous investigations are contributed to the influence of impurities, especially carbon, silicon and aluminum. α and γ-iron form solid solutions with boron. Two compounds were found and the structure determined by X-ray photographs. The iron side of the equilibrium systems iron–beryllium and iron–aluminum has been newly established corresponding to the results of thermal and microscopic investigations. Both systems show a closed gamma iron field. The maximum solubility of beryllium in γ-Fe amounts to 0.39% at 1100° C. The maximum solubility of Al in γ-Fe amounts to about 1% at 1126° C., which is in satisfactory agreement with the results of Iwasé and Murakami. Beryllium and aluminum form solid solutions with α-Fe by substitution of atoms. GN

Shrinkage in White Cast Iron. H. A. SCHWARTZ. *Preprint* 29-10, *American Foundrymen's Association*, pages 205–234.

The paper concerns itself with the formation of porous spots during the freezing of white cast iron, discusses the mechanism of the formation of these spots, deals in detail with the changes of density on freezing. A new simple method, especially suited for practical application, is described to determine the mentioned type of shrinkage. The given data show that cast irons with 2.5% carbon are less prone to shrinks than either higher or lower carbon materials. Cold pouring seems generally to promote sound castings. The percentage of voids can be represented by the formula S = 0.398 Carbon + 1.22 Silicon −0.933. Shrinkage (voids) increases with increase of carbon and silicon content. The solution of the problem of reducing shrinkage of white cast iron primarily lies along lines other than carbon and silicon control. GN

The Influence of Size of Section on the Strength of Grey Cast Iron. J. G. PEARCE. *Foundry Trade Journal*, Aug. 8, 1929, pages 101–102, 104, 106.

Paper read before the International Foundrymen's Congress. Author has previously suggested that there is a continuous change in strength of cast iron as the section alters. Discusses the influence of machining, of melting conditions on strength. Gives results of experiments and includes tables and charts. VSP

Investigations on the Tensile Strength and Structure of Cold-Rolled and Annealed Hoop Steels with Different Preliminary Treatment. (Festigkeitseigenschaften und Gefügeuntersuchungen an kaltgewalzten und geglühten Bandstählen verschiedener Vorbehandlung.) A. POMP & H. POELLEIN. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 10 (Report 127), pages 155–184.

The influence of cold-rolling with different distribution of pressure and different pass numbers on strain-hardening and structure of steel hoops with variable carbon content (0.10–1.44%) and different structure (lamellar pearlite, globular pearlite, sorbite) is investigated. The investigations on tensile strength, elongation and hardness are given in tables and diagrams. In a similar manner, yield point, tensile strength, elongation and structure of annealed hoops are investigated with various annealing temperatures and times. In annealing hoops with the higher degrees of cold deformation the formation of globular cementite was observed at about 400° C. Pure globular pearlite was obtained at 650° C. The influence of the annealing time ($1^1/_2$ to 10 hours) is less important. Conclusions for the annealing process in practice are drawn from the results. GN

Influence of Pass-Reduction and Annealing Temperature on the Physical Properties and Structure of Cold-Rolled Thin Sheets. (Einfluss der Stichabnahme und der Glühtemperatur auf die mechanischen Eigenschaften und das Gefüge von kaltgewalzten Feinblechen.) A. POMP & L. WALTHER. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol 11, No. 2 (Report 118), pages 31–35.

Cold-rolled sheets (Carbon: 0.04–0.07%, Si: trace, Mn: 0.45–0.52%) with different pass reductions and different number of passes were annealed for 3 hours at 650, 750 and 920° C. Regardless of the degree of deformation the best physical properties are obtained at 920° C. Annealing for 3 hours at 650° C. does not completely eliminate the effect of cold-working. Investigations of materials for deep-drawing — 30% reduction, annealed 3 hours at 750° C.—show that the number of passes has no influence on the application as deep-drawing material. GN

The Alloys of Beryllium with Iron. (Die Legierungen des Berylliums mit Eisen.) W. KROLL. *Metallwirtschaft*, Sept. 6, 1929, pages 881–883.

By additions of Ni the binary Be-steels could be improved: in case of 5% Ni, extremely fine grain was obtained and the required amount of Be dropped from 4–1%. The "absolutely attainable age hardness" is increased. The group of stainless steels also exhibited favorable results. Stress is laid upon (a) alloys of 20% Cr, 7% Ni, 1% Be as age-hardening V2A steel, (b) those steels of 12% Cr, 5% Ni, 1% Be which after aging possess hardness of high speed steel and exhibit greater hardness and greater corrosion resistance than the corresponding customary 12% Cr-steels, (c) the improvement of Be-invar steels which in quenched condition are very ductile and can be hardened by aging. The authors final conclusion may be cited: "Beryllium which did not fulfill the expectations in light alloys, has become the most important element of the last decade in heavy metals." EF

PHYSICAL, MECHANICAL AND MAGNETIC TESTING

Electromagnetic Testing for Mechanical Flaws in Steel Wire Ropes. T. F. WALL. *Electrician*, Sept. 13, 1929, page 302.

An abstract of a paper presented to the Institution of Electrical Engineers. An account of the researches resulting in the development of a design of an electromagnetic rope tester. The principle employed is to make use of a "search band of flux" which is linked with a search-coil system. a. c. excitation is preferable to d. c. excitation. An ink recording instrument is arranged to be operated by the induced e. m. f. in the search-coil system furnishing permanent records of tests so that the development of an incipient flaw may be carefully watched. It is concluded that for a. c. excitation at frequencies not greater than 20 cycles per sec., the flux is uniformly distributed throughout the whole cross-section of the rope, if the peak value of the flux density is not less than about 16,000 lines per $cm.^2$ A serious objection to the use of a. c. excitation at frequencies as high as 50 cycles per sec. is the large iron losses produced in the rope at the high densities. For wire rope testing it is important to use high values of the saturation, so that the disturbing effects of internal stresses become relatively unimportant. While a flaw of about 3% of the total section is detectable, a flaw of about 5% produces a pronounced effect, while a flaw of about 18% gives a very striking disturbance of the record. It is only when about 10% of the section fails that a watch need be kept on the faulty section to see whether it develops further. WHB

The Hardness of Steel Balls Used for the Determination of the Brinell Hardness Numbers of Materials. *Special Report* No. 16, *Department of Scientific and Industrial Research*, 30 pages.

The British Engineering Standards Association published in 1926 a Report (No. 240) giving tables of Brinell Hardness Numbers and methods to be used in making the tests. In the course of the preparation of this Report it appeared that owing to the fact that in some cases the Brinell hardness numbers depended upon the hardness of the balls used, a specification of the hardness of these steel balls was desirable. It was found that some research was required to enable such a specification to be prepared, and the British Engineering Standards Association accordingly asked the Department of Scientific and Industrial Research to investigate the matter. The necessary research was carried out at the National Physical Laboratory under the auspices of the Engineering Research Board. The present Report describes the results of the work done and indicates methods suitable for determining the hardness of the balls. Although the methods described are primarily intended for balls to be used for hardness testing, they are equally applicable to balls used in general engineering work.

STRUCTURE OF METALS AND ALLOYS

Structure and X-ray Analysis

Investigations on the Texture of Cold-Worked Metals. (Beiträge zur Kenntnis der Textur kaltverformter Metalle.) F. WEVER & W. E. SCHMID. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 7 (Report 124), pages 109–122.

The texture of cold worked aluminum and iron specimens was investigated. A special apparatus was constructed to obtain a parallelepipoid deformation. Debye-Scherrer photograms were taken of the deformed material, deformed in several steps. A modified method to simplify the evaluation of X-ray photograms by means of pole figures is given in the form of graphic nets. An additional device to facilitate the analysis of pole figures is described. The authors try to give an interpretation of the obtained textures. The known laws of the plastic deformation of cubic face-centered single crystals are used to explain the deformation of the crystal structure of a metal. The mechanism of plastic bending of crystals is discussed. The deformation structure is a stable final condition. The texture of aluminum is described as a superposition of axial textures. The discrepancies of the crystal position found by experiment in comparison with those to be expected based on theoretical considerations are examined and the results are explained by the process of deformation and strain-hardening of single crystals. The considerations are extended on the cubic space-centered structure providing that 011 is the slip plane and 111 the direction of slipping. The obtained structure of parallelepipoid-plane deformation is very similar to the texture of cold-rolled materials. GN

Critical Determinations of the K-, L_1- and M_1- levels of Lighter Elements. (Kritsche Bestimmungen des K-, L_1- und M_1- Niveaus für leichter Elemente.) B. C. MUKHERJEE & B. B. RAY. *Zeitschrift für Physik*, 1929, Vol. 57, No. 5–6, pages 345–353.

It is shown that the true K-absorption limits at which the electron flies into the infinite can be calculated from the precision measurements of the characteristic X-ray radiation and optical lines. With the aid of the regular doublette-distance of Sommerfeld the values for L_1 and M_1 are also derived. The curves for $\sqrt{\nu/R}$ as a function of the atomic number are plotted according to Bohr and Coster and their peculiarities discussed. Finally the critical potentials observed in lighter elements by the method of electron impact are compared with those measured in this paper. Results and comparisons are given for 35 elements. Ha

The New Securo Safety Apparatus for X-ray Installations. (Der neue Securo-Sicherheitsapparat für Röntgenanlagen.) E. FRITSCH. *Maschinenbau & Electrotechnik*, Oct. 1929, page 919.

A new safety device for protecting persons who work with X-ray equipments is described. EF

Investigations into the Structure of Heusler-alloys. (Strukturuntersuchungen an Heuschlerschen Legierungen.) S. VALENTINER & G. BECKER. *Zeitschrift für Physik*, 1929, Vol. 57, No. 5–6, pages 283–291.

Investigations into the lattice structure by means of X-rays in connection with metallographic observations and determination of change of length in aging of Heusler-alloys of a composition corresponding approximately to $Al(Cu, Mn)_2$ lead to the conclusion that the magnetic properties cannot be attributed to a certain lattice or phase component. Measuring method and test results are given and results of other investigators discussed. Ha

Contribution to Technical Investigation of Material by X-rays. (Beitrag zur technischen Materialuntersuchung mittels Röntgenstrahlen.) M. JONA. *Zeitschrift Osterichischen Ingenieur & Architekten Vereins*, Oct. 11, 1929, pages 427–428.

The author considers the following problems regarding material testing by X-rays: determination of structure, detection of changes in structure and corrosion. The influence of voltage is illustrated by practical data and the required exposure times are assembled in a second table. EF

X-ray Analysis of the Systems Copper–Antimony and Silver–Antimony. (Röntgenanalyse der Systeme Kupfer–Antimon und Silber–Antimon.) A. WESTGREN, G. HAEGG & S. ERIKSSON. *Zeitschrift für Physikalische Chemie*, Aug. 1929, Sec. B, pages 453–468.

An X-ray analysis of a series of Cu-Sb alloys has confirmed the equilibrium diagram given by Carpenter for the Cu–Sb system. Antimony can be dissolved in copper up to a considerable amount. The phase Cu_2Sb has a simple tetragonal lattice structure with six atoms in a unit cell with the following dimensions: $a_1 = 3.992$ A. U., $a_3 = 6.091$ A. U. and $a_3/a_1 = 1.526$. The structure of Cu_2Sb is apparently analogous to that of Fe_2As. The X-ray analysis of a series of Ag-Sb alloys has shown that the equilibrium diagram of Petrenko is not correct. The maximum solubility of Sb in As is about 5 atomic %. The lattice structure depends on temperature and Sb concentration. Various lattice dimensions are given. Ha

X-ray Analysis of the System Iron–Boron. (Röntgenanalyse des Eisen–Bor Systems.) T. BJURSTROEM & H. ARNFELT. *Zeitschrift für Physikalische Chemie*, Aug. 1929, Sec. B, pages 469–474.

An X-ray analysis of the Fe–B system has shown that in the concentration range 0–19% B, 2 phases occur, Fe_2B and FeB. The former, in agreement with findings of F. Wever, has a body-centered tetragonal lattice structure. The latter has a rhombic lattice. The investigations will be continued. A number of X-ray photographs are reproduced. Ha

The Probabilities of Prohibited s,d Transitions of Alkali-metals. (Ueber die Wahrscheinlichkeiten der Verboten s,d Uebegänge der Alkalimetalle.) W. PROKOFJEW. *Zeitschrift für Physik*, 1929, Vol. 57, No. 5–6, pages 387–393.

The abnormal dispersion of the prohibited lines 1s-3d of the alkali-metals was investigated; the probabilities of transition of these lines are approximately the same for all alkali-metals and are of the order 10^{-5} to 10^{-6}. The probability of the prohibited line 1s-4d of Cs is almost equal to the probability for the line 1s-3d. The ratios of intensities are determined with an accuracy of 10%. Results are tabulated for K, Rb, Cs and Na. Ha

The First Spectrum of Xenon. W. F. MEGGERS, T. L. DEBRUIN & C. J HUMPHREYS. *Bureau of Standards Journal of Research*, Nov. 1929, pages 731–763.

Although 30 years have passed since the discovery of xenon, comparatively little has been known about its spectra and all attempts to analyze the structure of the Xe_1 spectrum have been foiled by the incompleteness and inaccuracy of the available data. This situation has been improved, as follows: Discharge tubes were filled with pure Xe gas and operated so as to emit only the spectrum of neutral xenom atoms. This spectrum was photographed with quartz-prism and with diffraction grating spectrographs from the ultra-violet to the infra-red. Wave lengths ranging from 3442.77 to 10,107 A. U. have been determined for 318 lines and are supplemented by estimates of relative intensity. Analysis of these new data has resulted in the identification of spectral terms, combinations of which account for practically all of the observed lines. The normal state of the neutral Xe atom (s^2p^6) is represented by a single level, and successive excited states arise from the addition of s-, p-, d-, f- electrons to the xenon ion (S^2p^5). In the notation first introduced to describe the Ne_1 spectrum and subsequently used for A_1, Kr_1 and now also for Xe_1 the single level is called "p_0" and the term groups produced by addition of S-, p-, d-, f-electrons are designated "s," "p," "d and s," "x and y," respectively. These groups in the order named theoretically consist of 4, 10, 12 and 12 levels. Each group divides into 2 subgroups converging in the limit to the 2 levels of a ^2P term characterizing the normal state of the xenon ion. This subdivision is striking in Kr_1 but especially so in Xe_1 on account of the large separation (9621) of the Xe_{11} doublet. From the limits of the most regular series in the Xe_1 spectrum and from certain combinations the absolute value of the $1s_5$ term is established as 30,766.98 and all other term values are based on this one. The resonance lines in the extreme ultra-violet (1469.61 and 1295.56 A. U.) then fix the value of the largest term $p_0 = 97,835$ from which the ionization potential of 12.078 volts is deduced for neutral xenon atoms.

Metallography and Macrography

Metallography Simplified for Practical Use in Shop. E. PREUSS, G. BERNDT & M. v. SCHWARZ. *Iron Trade Review*, Aug. 8, 1929, pages 328–330.

Appendix Supplementing microscopic testing by other methods (concluded). Devoted to the determination of thermal expansion by means of the dilatometer, and to physical tests, such as fatigue, hardness, bending and notched bar impact tests. MS

Polishing of Metals on Pitch. (Das Polieren von Metallen auf Pech.) L. MOHR. *Zeitschrift für Metallkunde*, July 1929, page 234.

The author gives his experiences on preparing samples for microscopic examination the rim zones of which have to be examined so that formation of reliefs must be avoided. EF

On Etching of Metal-sections. (Ueber das Atzen von Metallschliffen.) L. MOHR. *Apparatebau*, June 14, 1929, pages 135–137.

General survey of various methods of etching of metals is given. EF

CORROSION, EROSION, OXIDATION, PASSIVITY AND PROTECTION OF METALS AND ALLOYS

Calorizing Steel Against Oxidation and Corrosion at High Temperatures. B. J. SAYLES. *Brass World*, Nov. 1929, pages 264–265.

Advantages of aluminized material in service operations involved in calorizing are pointed out. Results of tests of strips of various metals arranged so that part of the strip was immersed in circulating liquid and the upper portions in contact with vaporized oil and extending over a 2-year period indicate the inside of calorized tubes are immune to sulphur corrosion. WHB

Protecting Aluminum and Its Alloys from Corrosion. H. SUTTON. *Brass World*, Dec. 1929, pages 287–289.

An abridged report of the opening meeting of the British Electroplating Society. Various processes of anodic oxidation of aluminum and its alloys are outlined. The anodic oxidation process tends to open up and reveal any defects such as laps, seams, etc., in the metal occurring at the surface also to disclose any attempts to plug up blowholes, holes drilled in the wrong place, etc. The protection due to anodic oxidation is enhanced by the subsequent application of suitable paints, or enamel or by a grease. A discussion follows. WHB

Aluminium. A. G. C. GWYER. *Electrician*, Nov. 29, 1929, page 676.

Tests for the measurement of the extent of corrosion of aluminum are needed. Two tests due to Mylius, are worthy of mention. In one the specimen is immersed in hydrochloric acid contained in a flask under standard conditions and in measuring the rise in temperature of the acid, it being assumed that the reaction velocity may be taken as a measure of corrodibility. In the other test, a sample of standard area is immersed in sodium chloride solution of given concentration to which a definite amount of hydrogen peroxide has been added. After 24 hrs. the aluminum hydroxide is filtered off, ignited and weighed. A great variety of paints, lacquers and cellulose mixtures have proven good preservatives and "anodic oxidation" is one of the most successful and important methods of protection. In America a composite metal is produced with an outer layer consisting of very high purity aluminum. In Germany the addition of comparatively small amounts of antimony to aluminum has given rise to a highly protective film which is rapidly reformed after abrasion, etc. High-silicon alloys are good from the standpoint of corrosion. WHB

The Influence of Depolarization upon the Corrosion Speed and Its Practical Application. (Der Einfluss der Depolarization auf die Rostgeschwindigkeit und ihre praktische Nutanwendung.) F. TÖDT. *Korrosion & Metallschutz*, Aug. 1929, pages 169–174.

Iron corrosion is principally based on the depolarizing effect of O_2 which diffuses to the cathode areas of the local elements predominantly consisting of oxidized metal. The reported investigations prove that the corrosion effect cannot only be measured by the O_2-depolarization current intensity but that the gravimetric corrosion found on a certain Fe-area satisfactorily coincides with the corrosion derived from the depolarization current between an equally large Pt-surface connected with Fe. All corroding iron surfaces seem to consist of local elements of active and passive iron. The new measurement transfers the reactions at the cathode to a noble metal surface. The practical application intends to (a) directly indicate the corrosive or oxidizing effect of solutions and (b) demonstrate the corrosion of metals in regard to the promoting and preventing influences at the metal surface. EF

Aluminum Roofs for Halls and Shops. Corrosion Protection of Aluminum Sheets by Anodic Oxidation. (Aluminiumdächer für Hallen- und Werkstattbauten. Korrosionsschutz der Aluminiumbleche durch anodische Oxidation.) H. SCHOLZ. *Aluminium Zeitschrift*, May 15, 1929, pages 1–4.

The author examines the possibilities of utilization of Al in construction work and particularly discusses the corrosion resistance due to anodic oxidation. EF

Comparative Investigations of Transition Resistance and Rust Protection Effect on Protected Iron Pipes. (Vergleichende Untersuchungen von Uebergangswiderstand und Rostschutzwirkung an oberflächengeschützten Eisenrohren.) W. BECK & K. JAKOBSOHN. *Korrosion & Metallschutz*, Sept. 1929, pages 202–207.

The Haber apparatus accordingly was modified for the determination of transition resistances which are tabulated. The iron pipes were protected by commercial "isolation bandages" and exposed to the corrosion attack of moist ground, acid mine water, artificial North Sea water and tap water saturated with gypsum. The results prove that the magnitude of transition resistance does not necessarily represent a criterion for the corrosion preventing ability of rust protection materials. The influence of wax layers is discussed. EF

Contribution to the Characteristic of the V2A Steel. (Ein Betrag zur Charakteristik des V2A Stahls.) E. LIEBREICH. *Korrosion & Metallschutz*, Sept. 1929, pages 199–202.

The author reports on investigations of potential measurements of V2A steel wire in 1/10% H_2SO_4 containing a Pt electrode. Feeble but slowly increasing currents were sent through this cell. The potential of the wire was checked by a normal electrode. The results are interpreted and graphically presented in several diagrams. EF

Corrosion of Lead Cables. (Die Bleikabelkorrosion.) H. RÖHRIG. *Gummi Zeitung*, May 17, 1929, pages 1866–1868.

After a general review of the corrosion resistance of lead the influences of soil, sea-water, cement and mortar are discussed. EF

A Study of Some Cast Irons Containing Nickel and Copper. (Recherches sur quelques fontes au nickel et au cuivre.) MARCEL BALLAY. *Revue de Metallurgie*, Oct. 1929, pages 538–553.

The resistance to corrosion and scaling was studied on a group of cast irons containing 3% C, 1.5–2% silicon to which alloying elements were added to produce metals of the following types: low Ni (.06%); low Cr (.05%); high Ni (13.73%); high Cu (3.17–5.07%); Cu-Cr (3.25–.65%); Ni-Cu (14.37–5.10%); Ni-Cu-Cr (7.15–6.00–2%); All alloys were machinable though the structure was widely different, those with the higher content of alloys consisting of graphite, martensite and austenite. Corrosion tests were made in cold 5% H_2SO_4, cold 5% H_2SO_4 – 5% H_2O_2, in 60° Be H_2SO_4 at 90–100° C., in 10% H_2SO_4 at 90–100°C., in cold 5% HCl,in salt spray, sea-water and cold 25% acetic acid. Austenitic Ni-Cu-Cr irons show a better resistance to corrosion in cold diluted acids even in the presence of H_2O_2 than bronze or brass; in salt spray they resist much better than the ordinary irons, though in sea-water being superior to bronze they corrode faster than brass. Hot concentrated H_2SO_4 attacks them rapidly. Specimens were heated intermittently for 330, 88, 40 and 100 hours respectively at 500, 625–650, 800–850 and 925° C. Heating at 500° does not affect the ordinary irons but partially decomposes austenite of high Ni-Cu alloy in martensite. The decomposition of pearlite in ordinary irons is pronounced at 600° and depends on Si content. Ni-Cu-Cr alloy is unaffected by it. At 850° ordinary irons do not show any pearlite while Ni-Cu-Cr alloy remains unchanged. The hardness of Ni-free irons is much reduced by this treatment at 925°. All alloys with the exception of high Ni type were badly scaled. The mechanical properties of austenitic alloys vary much with the composition. Decrease in Si content and increase in Cr raise them, without affecting the machinability. Ni-Cu-Cr cast irons cannot claim the properties of stainless steels but furnish a good material for cheaper kinds of work which can be made by casting. JFG

Corrosion Testing Apparatus. D. F. Othmer. *Industrial and Engineering Chemistry, Analytical Edition*, Oct. 15, 1929, page 209.

In this apparatus, consisting of a heater, flask, packed column and reflux condenser, the test pieces are in contact with saturated vapor and boiling liquid at all times. Metallic salts are constantly washed away and the wash liquid is always clean. MEH

Lanoline Rust Preventers. *Special Report* No. 12, *Engineering Research Department of Scientific and Industrial Research*, 22 pages.

The investigations described in this report have been carried out at the National Laboratory under the supervision of the Engineering Co-ordinating Research Board of the Department. A preliminary examination of a number of representative rust-preventing mixtures showed that Lanoline was superior to the other materials tested. An account of the examination of samples of Lanoline from various sources and tests over long periods under the usual conditions of storage is included. The report concludes with details of mixtures which have been found most satisfactory and with specifications for the necessary materials produced in part from specifications published by the British Engineering Standards Association.

The Influence of Paints on the Tensile Strength of Connections with Rivets. (Der Einfluss von Farbschichten auf die Festigkeit von Nietverbindungen.) E. Hegen. *Krupp'sche Monatshefte*, Aug.-Sept. 1929, pages 137–138.

The tensile strength of rivet connections was examined to get information on the influence of protective paints. In 3 groups connections without paint, with white lead and oil and lead ochre were investigated. Paints influence the tensile strength in an unfavorable manner. The rule of the Deutsche Reichsbahn which prescribes four layers of lead ochre is no more unfavorable than a simple oil white lead paint. GN

Corrosion-Resistant Metals and Alloys in Dairy Equipment. C. L. Mantell. *American Metal Market*, Oct. 19, 1929, pages 7 and 10.

An attempt to correlate data from a number of investigations and to summarize the results from an engineering viewpoint. Nickel-chromium steels of the austenitic type offer the best possibilities under carefully controlled manufacturing conditions, as corrosion-resisting alloys for use in the dairy industry. All-tin, all-nickel and heavily tinned copper come next in favor. Aluminum—used widely abroad is satisfactory when careful selection of cleaners and sterilizers is made. Correct design of equipment is essential as carelessness in the specification of minor details or accessories may introduce corrosive effects offsetting the usual resistance of the metals or alloys. WHB

Insoluble Sulphates and Passivity. L. McCulloch. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 283–286.

Fe, Ni and Cr have anhydrous sulphates which go into solution with difficulty. These sulphates may compose the films which cause the passivity of these metals in sulphuric acid. Co and Cr anodes dissolve readily because they have easily soluble anodic products. It is suggested that any slowly soluble anode product may be the cause of passivity. EF

Solution Potentials of Aluminum Alloys in Relation to Corrosion. J. D. Edwards & C. S. Taylor. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 351–358.

Potential measurements of Al vs. Al-alloys have been carried out on a large scale, important in explaining the behavior of the metals in contact under corrosive conditions. EF

Accelerated Corrosion Tests for Coatings of the Iron Phosphate Type. E. M. Baker, A. J. Herzig & R. M. Parke. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 161–170.

Coatings of the iron phosphate type, often used in place of certain electroplated coatings, were produced on mild steels from solutions containing various concentrations of iron phosphate and phosphoric acid. The salt-spray test and intermittent immersion test in distilled water and 0.01 in sulphuric acid were found to be suitable for evaluating the quality of the coatings. Some observations are presented on the effect of bath composition on the quality of coating and on the optimum bath composition for best quality. EF

The Corrosion Rate of Ferro-Nickel Alloys. C. G. Fink & C. M. DeCroly. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 121–155.

Systematic studies were made of (a) the corrosion of one ferro-nickel alloy in different corrosive agents at different concentrations; (b) a number of alloys of the iron-nickel series in the same corrosive agent at the same temperature; (c) the influence of the addition of passifying anions on the rate of corrosion of different alloys in H_2SO_4 solutions; (d) the influence of protective films on the rate of corrosion; (e) the relationship between the contact potential of the alloy against the solutions used for testing and the composition of the alloy and the concentration of the solutions. The intermittent corrosion test according to the A. S. T. M. was applied. For details of the comprehensive investigations, the original must be consulted which in summary indicates that the rate of corrosion is primarily dependent upon the rate of oxidation by the oxygen dissolved in the H_2SO_4 and not by the rate of ionization of the metal. EF

Influence of Filling Materials on Corrosion Resistance of Aluminum Tubes. (Einfluss der Füllmasse auf die Widerstandsfähigkeit der Aluminium tuben.) J. Augustin. *Chemiker Zeitung*, Sept. 4, 1929, page 692.

Attack of commercial materials in Aluminum tubes (99.5% Al) and protection are considered. EF

On Old and New Methods for the Determination of Corrosion and Corrosion Protection. (Ueber alte und neue Verfahren zur Feststellung der Korrosion und des Korrosionsschutz.) L. W. Haase. *Gas- und Wasserfach*, July 15, 1929, pages 1129–1136.

The author critically discusses the numerous methods to determine the degree of corrosion on the one hand and the corroding power of various solutions upon the different metals on the other. EF

Corrosion Protection of Aluminum-Fittings by Means of Anodic Oxidation. (Korrosionsschutz von Aluminium Armaturen durch anodische Oxydation.) W. Eisner von Gronow. *Gas- und Wasserfach*, May 4, 1929, pages 429–436.

The anodic oxidation of Al in an electrolyte of 3% aqueous solution of chromic acid or an equivalent salt of chromic acid is described. Anode: Al-parts which are to be oxidized. Cathode: Graphite. Bath temperature: 40° C. Voltage: increasing from 0 to 40 Volts in the first 15 minutes, from 35–50 Volts within the next five minutes, this voltage is kept constant for further five minutes. Total time: one hour. The current density varies with different Al alloys. Usually Al sheets: 0.3–0.4 amp./dm.^{2} For other alloys 10 times as large or still larger current densities. Practical advices based on long experience are given to avoid failures. Limitations of applicability are considered. EF

Corrosion and Metal Protection in Gas Works Operation. (Korrosion und Metallschutz im Gaswerksbetrieb.) Dr. Maass. *Gas- und Wasserfach*, June 8, 1929, pages 563–578.

The paper reviews the various corrosion theories and demonstrates the occurrence of corrosion in practice and suggests protection methods. EF

Corrosion Tests with Iron. (Korrosionsversuche mit Eisen.) W. van Wüllen. *Gas- und Wasserfach*, May 11, 1929, pages 456–458.

The paper which includes 40 references gives a condensed review of the most important investigations concerning corrosion tests with iron. EF

Corrosiveness of Soils with Respect to Iron and Steel. Preliminary Studies. H. D. Holler. *Industrial and Engineering Chemistry*, Aug. 1929, pages 750–755.

Presented before the Division of Industrial and Engineering Chemistry at the Columbus Meeting of the American Chemical Society, April 1929. A method of studying soil corrosion based on the relation of salt content, acidity and corrosiveness of soil to rainfall, is suggested. It is found that a relation exists between the ability of a soil to react on iron with liberation of hydrogen, and its total acidity as indicated by titration. Soils from 47 localities have been investigated. The reaction of soil on iron continues until a pH value of about 9.5 is reached. MEH

Acid and Corrosion Resistant Alloys. C. E. Plummer. *American Metal Market*, Oct. 16, 1929, pages 8, 10; Oct. 17, 1929, page 10.

A paper read before the Tri-City Branch of the National Association of Purchasing Agents, Davenport, Iowa, Feb. 18, 1929. Data are given on resistant metals and alloys. The selection of a metal or an alloy should be determined by consideration of the following characteristics: (1) good casting properties; (2) forgeability; (3) machinability; (4) strength; and (5) immunity to the attack of as many destructive agencies as possible. An alloy containing 20% molybdenum, 20% iron, and remainder approximately nickel is very resistant to HCl, also to salt spray, hydrogen sulphide, and sulphurous acid. It is, however, attacked by moist chlorine and by hot nitric acid. It may be cast in sand, forged, hot or cold rolled and welded using an oxy-acetylene torch. An alloy containing 10–11% silicon, 1½-2% aluminum, 3% copper and the balance approximately nickel produces tough castings and is resistant to hydrochloric acid, sulphuric acid and phosphoric acid. It is not easily machined. A number of other alloys are discussed as to composition, physical and chemical properties WHB

INDUSTRIAL USES AND APPLICATIONS

The Emmet Mercury Vapor Process—Results Accomplished. W. J R. Emmet. *General Electric Review*, Nov. 1929, pages 619–621.

A brief illustrated description of the installation of the Emmet Mercury vapor process in the Meadows Station of the Hartford Electric Co. The mercury turbine is rated at 10,000 kw. and 125,000 lbs. of steam per hr. After 3 weeks operation some difficulties developed which are being overcome. During operation the unit was saving about $800 per day in fuel alone. No erosion was evident in the turbine, the furnace showed no deterioration, and the heating surface was easily kept clean. WHB

Rolled Steel in the Construction of Electrical Machines. Henry G. Reist. *General Electric Review*, Nov. 1929, pages 597–601.

Radical changes in construction of mechanical parts of large rotating electrical parts are indicated for the substitution of rolled steel for castings. Twelve illustrations of parts are shown. Advantages are claimed in quality, time and cost, and the benefits are so great that the new type of construction has been widely adopted in the U. S. A. and in Europe. WHB

Sag Charts for Copper Conductors. W. T. Taylor. *Electrician*, Nov. 1, 1929, pages 522–523.

A series of curves give sag value for copper conductors (⅜ in. ice loading) in terms of variable span length. Means of finding the stringing tension in still air and sags for maximum loading conditions are indicated. WHB

Ordinary Commercial Cylinders for the "Permanent" Gases. Summary of Recommendations (revised). *Gas Cylinders Research Committee, Department of Scientific and Industrial Research*, 8 pages.

The First Report of the Gas Cylinders Research Committee, which is now out of print, dealt with cylinders for the transport under ordinary commercial conditions of the permanent gases. The Report recommended the use of 0.45 percent carbon steel for the construction of the cylinders as an alternative to the 0.25 percent carbon steel previously used, with a view to a reduction in the weight of cylinders. It was decided to republish the summary of recommendations contained in it, and the Gas Cylinders Research Committee have taken the opportunity to make certain revisions. Some of these revisions merely represent alterations of wording, while others consist of some change in the substance of the recommendations. Certain new clauses have also been added. In their present form, the recommendations supersede the original.

The Installation of Boiler Tubes. (Das Einwalzen von Rohren.) E. Siebel. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 8, pages 123–139.

The author investigated the deformation of shape and the power of adherence in tube connections and in rolling tubes into header plates. The experiments cover basic open-hearth and nickel steels. GN

Chromium-molybdenum Steel Tubing Fuselage Construction. J. H. Kindelberger. *Journal Society Automotive Engineers*, Nov. 1929, pages 474–477.

Southern California Section Paper. The article describes the application of chromium-molybdenum steels as tubes in fuselage construction of airplanes. GN

The Possible Use of Beryllium in Aircraft Construction. H. W. Gillett. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 218–222; *Canadian Chemistry & Metallurgy*, Oct. 1929, page 276.

Properties possessed by beryllium that should make it attractive for aircraft construction are: specific gravity, 1.84, melting point 1260° F., a modulus of elasticity almost up to that of steel and 3 times that of magnesium, a coefficient of thermal expansion approximating that of cast iron, retention of a high polish in air, a more ready attack by salt water than aluminum but far less than pure magnesium. It is hard and brittle. Quantity demand is necessary to sufficiently reduce the cost of the metal to make it economically attractive and high-beryllium alloys offer the best proposition at present. WHB-EF

Aluminum and Its Alloys in Aircraft. T. W. Bossert. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 360–365.

Properties of Al-alloys in aircraft construction are outlined and characteristic examples of their application are described. EF

Magnesium and Its Alloys in Aircraft. W. G. Harvey. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 367–377.

More recent steps in utilization of Mg in airplane construction are considered, discovery of methods of purification of the metal and heat-treatment of its alloys, corrosion stability of Mg-Mn alloys, forging especially for propeller blades, castings, etc. The properties of the Mg-alloys are tabulated. EF

HEAT TREATMENT

Heat Treatment Well Grounded in Experience but not yet a Science. Joseph R. Miller. *Iron Age*, Aug. 29, 1929, page 513.

Formulated methods now followed in routine heat treatments appear to have reached a scientific basis. The fact remains that our formulations are based on experimentation rather than upon exact science or mathematical theory. From experiments it is well determined that transformation in steel structure is due to rate of cooling. Also, certain microstructures are different simply in fineness of structure. X-rays are an aid to the heat treater in observing ultimate structure that is being transformed. VSP

Effect of Heat Treatment on Properties and Microstructure of Britannia Metal. B. Egeberg & H. B. Smith. *Technical Publication* No. 244, *American Institute of Mining and Metallurgical Engineers*, 14 pages.

Abnormal behavior was noticed in Britannia metal after cold rolling and a theory has been developed based on microscopic evidence. When cold-rolled less than 40–50%, the metal becomes slightly harder but softens after heat treatment. At higher reductions the metal behaves in a contrary manner becoming continuously softer the more it is cold-rolled. In this state, heat-treatment results in an increase of hardness and strength. Elongation, bending, hardness and other tests were carried out to study the effect of cold-rolling. EF

Heat Treating Aluminum Alloys. Robert J. Anderson. *Iron Age*, Aug. 29, 1929, pages 514–516.

Classifies heat treatment processes in the aluminum field. In the past few years much has been learned about theory and practice of alloy heat treatment. Gives views on quenching and aging. Principles of annealing of cold worked aluminum are the same as those applying to metals in general. Continuous or flash annealing for aluminum circles, sheet, and coils has been found advantageous. Discusses properties of alloys, heat treating equipment and uses of heat treated aluminum alloys. VSP

A Year's Progress in Steel Treating. H. F. Moore. *Iron Age*, Aug. 29, 1929, pages 517–518.

Feature of past year has been the tendency to a fairly general agreement as to principles of heat treating, especially of iron and steel. An outstanding feature during the year is the development of nitriding process for hardening the surface of steel. Another advancement is the heat treatment and alloying of gray cast iron, capable of giving a much better structural material than ordinary gray iron. Other developments noted are: case carburizing, steel rail heat treatment and new alloy known as tungsten carbide. VSP

Heat Treating Aircraft Parts. Horace C. Knerr. *Iron Age*, Aug. 29, 1929, pages 519–524.

Describes method of heat treating delicate parts used in aircraft construction. Properties of chrome-molybdenum steels. Oil quenching produces as good or better tensile strength than water and gives a higher combination of strength and ductility. Manufacturing of aircraft parts consists in cutting to size, bending, forming and assembling by welding. Design of special furnaces for heat treating. These furnaces are also finding many uses outside of aircraft industry, wherever parts of thin section and long length must be treated without distortion. Numerous tables and illustrations are included. VSP

Drawing

The Effects with Tempering Quenched Chromium and Manganese Steels. (Anlassvorgänge in abgeschreckten Chrom und Manganstahlen.) H. Goerisch. *Stahl und Eisen*, Aug. 29, 1929, pages 1272–1274.

Report of the Institut für mechanische Technologie und Metallkunde der Technischen Hochschule, Berlin. 2 Heft, Berlin 1928, Verlag Springer. The paper gives the results of dilatometric investigations on tempering effects in chromium and manganese steels. The apparatus is described. A steel without dilatation could not be found. GN

On Drawing of Austenitic Steels. (Etude sur le revenue des aciers en etat de contrainte austenitique.) Andre Michel & Paul Benazet. *Revue de Metallurgie*, Sept. 1929, pages 455–463.

The allotropic transformations of steel can take place either suddenly, as in common carbon steels, or gradually as in high chromium alloys. In the first case a dilatometer will indicate a pronounced elongation, in the second even a contraction can be observed. The rate of heating has a very pronounced influence on the character of transformation curve of the second type of steels affecting the first but very slightly. Assuming that the contraction is caused by the precipitation of the carbides from the supersaturated in regard to carbon austenite which frees the normal austenite to transform into martensite, a series of experiments on two types of steel characteristic of both types (C 0.94, Cr 5.8, W 5.6, Co 25% and C 0.54, Si 0.27, Mn 0.45, Cr 19.0, Ni 0.80%) were conducted by changing time, temperatures and rate of heating of the heating and cooling cycles. The changes were followed with a set up of Chevenard's dilatometer which is fully described. By proper adjustment of the conditions it was possible to induce in both types of steels transformations characteristic of the other. Long heating under the critical not only precipitates the carbides but transforms gamma iron into alpha. JBG

Annealing

Short-Cycle Malleabilizing Improves Product and Saves Time. *Electrical World*, Nov. 16, 1929, page 989.

The General Electric Co. has announced a process for the production of malleable iron in 30 hours or less. This short-cycle annealing process eliminates boxes and packing material, reduces labor, eliminates hard cleaning, reduces time resulting in less inventory, permits shorter deliveries and a saving in space and furnace investment, lowers cost, and controls anneal by varying cycle to meet variation in metal composition. WHB

Case Hardening and Nitrogen Hardening

Researches on Nitriding Steels. Oscar E. Harder, James T. Gow & Lowell A. Willey. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 119–144.

Includes discussion. Paper presented before the Nitriding Symposium Eleventh Annual Convention American Society for Steel Treating, Cleveland, Friday, October 13, 1929, 12:00 n. Data are given showing Rockwell and Brinell hardness-depth readings on a variety of steels. A further series of nitrided specimens shows variation of dissociation inversely proportional to the rate of flow of ammonia. Hardness depth curves (Vickers) are given for these. Observations of nitriding by means of moist ammonia and dry ammonia were made. Maximum hardness of the nitrided case was obtained by treating at 875° F. Hardness decreased for increase in temperature above this point. Evidence of loss of carbon content during nitriding is presented. ESC

A Few Practical Fundamentals of the Nitriding Process. H. W. McQuaid & W. J. Ketcham. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 183–203.

Includes discussion. Paper presented at the Nitriding Symposium Eleventh Annual Meeting American Society for Steel Treating, Friday, September 13, 1929, 3:30 p.m. Hardness-depth curves are shown for decarburized and undecarburized nitrided surfaces yield consistently higher values for the hardness on the decarburized surface. Hardness-depth curves on specimens case hardened in a sealed retort, in an atmosphere replenished by a stream of ammonia at varying rates of flow, in an atmosphere, stirred by means of a fan, and rotated in the retort chamber indicate improvement in the character of the case obtained under the latter conditions over that of the first. Scrap tantalum surrounding the specimen yielded no improvement in the case produced. Specimens nitrided for 15 hours at 1500° and 10 hours at 975° showed greater penetration but lower hardness than a 25 hour treatment at 975°. ESC

Short Time Nitriding of Steels in Molten Cyanides. A. B. Kinsel & J. J. Egan. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 175–182.

Paper presented at the Nitriding Symposium Eleventh Annual Meeting of the American Society for Steel Treating, Cleveland, Friday, September 13, 1929, 3:00 p.m. A method of nitriding by means of a sodium and potassium cyanide bath is described. A very thin case of higher hardness than the ammonia treatment is obtained. The case has considerable wear and corrosion resistance but does not withstand high local stress as effectively as the deeper case. ESC

The White Layer in Gun Tubes and Its Relation to the Base of Nitrided Chromium Aluminum Steel. H. H. Lester. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 1–17.

Includes discussion. Paper presented at the Nitriding Symposium Eleventh Annual Convention American Society for Steel Treating, Cleveland, Friday, September 13, 1929, 10:00 a.m. Micrographic and radiographic studies of the "white layer" formed in the bore of gun tubes during service are shown to indicate this is a nitriding of the bore surface. ESC

The Nitriding Process. Dr. Adolph Fry. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 111–118.

Paper presented before the Nitriding Symposium Eleventh Annual Convention American Society for Steel Treating, Cleveland, October 13, 1929, 11:30 a.m. This paper deals with a discussion of results and with the possibilities of development of the nitriding process. It discusses the practical results which have been obtained. Then it considers the influence of high pressure nitriding and especially the influence of nitriding at high temperatures. The author deals briefly with the theory of nitriding and suggests some proposed theoretical work to be done. He presents data concerning the theory of nitriding hardness. ESC

Investigations in Nitriding. Robert Sergeson. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 145–174.

Includes discussion. Paper presented at the Nitriding Symposium Eleventh Annual Meeting American Society for Steel Treating, Cleveland Friday, September 13, 1929, 2:30 p.m. Chromium-nickel-aluminum steels were discarded in favor of chromium-aluminum or chromium-aluminum-molybdenum for nitriding. The former proved unsatisfactory because of temper brittleness. The latter yields greatest toughness. Vickers hardness depth curves of nitrided and carburized cases are shown. The nitrided case penetrates no more than 0.030 inch whereas the carburized case yields greater hardness values up to 0.060 inch. Similar curves indicate no material change due to reheating nitrided specimens for thirty minutes at 1000°, 1100°, 1200° and up to 1800° F. Series of nitriding operations were carried out at temperatures of 950° to 1200° F. for equal time cycles and with rates of flow of 50, 200 and 500 liters per hour. Vickers hardness depth curves are shown. At temperatures above 950° F. increased flow yielded increased hardness. At higher temperatures hardness decreases and penetration increases. Satisfactory results may be obtained with less than 1% chromium and smaller aluminum contents. Evidence is presented to indicate that nickel with chromium and aluminum yields high hardness, and nickel with molybdenum and aluminum yields lower hardness and greater penetration. Nitriding for 15 hours at 950°, 225 liters per hour flow followed by 15 hours at 1180°, 475 liters per hour flow yields a higher hardness than nitriding at the 1180° and following with a 950° treatment. Decarburized surfaces when nitrided become brittle. Microscopic examinations of the Vickers and Rockwell impressions indicate brittleness degree of case. ESC

Observations on the Iron–Nitrogen System. Samuel Epstein. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 19–65.

Includes discussion. Paper presented at the Nitriding Symposium Eleventh Annual Convention American Society for Steel Treating, Cleveland, Friday, Sept. 13, 1929, 10:30 a.m. By means of thermal analyses, microscopic examinations and X-ray analyses of nitrided electrolytic iron specimens, a study has been made of the iron–nitrogen system. From the data obtained and with the two existing diagrams of Sawyer and Fry as a basis a modified iron-nitrogen thermal diagram has been drawn. The upper temperature horizontal noted by Sawyer was also observed but this has been ascribed to a peritectoid instead of a eutectoid transformation. Three nitrided layers were observed, whereas Fry noted only two. The three layers have been designed as Fe_2N, Fe_4N and Fe_6N. Observations on several specimens of aluminum molybdenum nitriding steel are also described. ESC

A Study of the Nitriding Process. V. O. Homerberg & J. P. Walsted. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 67–110.

Includes discussion. Paper presented at the Nitriding Symposium Eleventh Annual Convention American Society for Steel Treating, Cleveland, Friday, September 13, 1929, 11:00 a.m. Equipment for case-hardening by nitriding is described. Data regarding the physical properties of the nitriding steels before and after treatment are given. Micro structure is given for various heat treatments of nitrided specimens. Information is presented concerning the character of nitrided case obtained at various temperatures of 800–1400°. It is observed that the depth of case increases with the increase of temperature, but hardness decreases with increase of temperature. The commercial nitriding steels are found not to be affected by "temper brittleness." Protection against nitriding may be obtained by nickel plating, coating with tin or solder or painting with a suspension of stannous or stannic oxide. It is recommended that decarburized surfaces be eliminated to prevent spalling of the case; strains be eliminated by previous heat treatment in order to prevent warping. ESC

Nitrogen Hardening. VI. (Rules of Production for Nitrided Motor Cylinders.) *Krupp'sche Monashafte*, June 1929, pages 59–61.

The application of nitrogen hardening for engine and cylinder liners internal-combustion engines is such an important improvement as regards service time, oil, consumption and efficiency that different plants in Germany and abroad apply these continuously. In consequence of its heat resistance the extreme hardness of the nitrided layer is not influenced by an increase of temperature during the action of the working surfaces. The wearing of the working surfaces of engine and piston, therefore, is very small. The production of the working surfaces of pistons, cylinders and liners is in principle as follows: (1) The nitrided steels F. P. 13 or F. P. 15 are used in tube form. The wall thickness of the tube depends on the shape and diameter of the cylinder. The wall thickness for a cylinder with $2^3/_4''$ inner diameter should be at least $^{13}/_{32}''$, above $2^3/_4''$ about $^{15}/_{32}''$. (2) Improving of the material to 114,000–121,000 lb./in.^{2} tensile strength. (3) Rough machining inside with an additional stock of about $^1/_{128}''$ per diameter. Rough machining outside according to the shape, the wall thickness would at least amount to $^1/_4''$ after rough machining. (4) Tin. The whole part is thinly but well tinned. (5) In finish machining the working surface has an under-dimension of about 0.003–0.004″ per diameter when the cylinders are ground strictly to size, or an underdimension of 0.001–0.0016″ per diameter when the machine parts are polished only inside, which is necessary in many cases. (6) Nitriding. (7) Finish machining outside. The smallest admissible wall thickness is about $^1/_{128}$–$^3/_{16}''$. (8) Inserting. Cylinder liners are suitably pressed into the block, drilled with a shrinkage of about 0.004″ and uniformly heated in an oil bath up to 200–250° C. (9) Grinding to dimension inside and, if required, polishing. A high polish is of high importance for working qualities. GN

Use of Nitrided Steel in High Temperature-High Pressure Steam Service. VINCENT T. MALCOLM. *Special Edition, Transactions American Society for Steel Treating*, Oct. 1929, pages 205–216.

Paper presented before the Nitriding Symposium Eleventh Annual Meeting American Society for Steel Treating, Cleveland, Friday, September 13, 1929, 4:00 p. m. Nitrided steels for the trim on valves subjected to high temperature and high pressure steam service is recommended. It is indicated that nitrided steel has the ability to resist stress at high temperature over long periods of time; it is corrosion resistant; has a high thermal expansion corresponding closely to carbon steel and possesses extreme resistance to wear and abrasion. Only severe service conditions to which nitrided steels have been subjected are described, no details of methods and tests are given. ESC

JOINING OF METALS AND ALLOYS

Brazing

Electric Brazing in Hydrogen Atmosphere Furnace. *Brass World*, Oct. 1929, page 244.

The General Electric Co., Schenectady, N. Y. has developed a new type of furnace for brazing with copper flux in an atmosphere of hydrogen. The furnace is of the tunnel type resting on supports above a roller conveyor. On the conveyor rests a row of trays on which the work is loaded. The furnace has openings at either end in the bottom. It is heated at the entrance end and cooled at the other end. Motor operated elevators, located beneath the furnace openings, raise the trays into or lower them from the furnace. The operation is outlined. WHB

Soldering

Repairs of Aluminum Parts by Soldering and Welding. (Ausbesserungsmöglichkeiten von Aluminum-Werkstücken durch Löten und Schweissen.) H. REININGER. *Werkstattstechnik*, Sept. 15, 1929, pages 525–532.

The author describes the various kinds of soldering and welding, gives composition and application of suitable solders for aluminum. Description of mechanical and chemical preparation of pieces to be soldered. Summarized comparison of the most important properties of soldered connections and observed failures. GN

Solder for Rustless Steel. *American Metal Market*, Oct. 22, 1929, page 8.

From "Die Metallbörse." An alloy of the following composition works satisfactorily as a solder for rustless steel: manganese 40%, copper 50%, nickel 10%. This alloy melts at 900° C., it possesses high resistance to chemical attack also the approximate color of rustless steel. Fluidity, color or alloying property may be influenced by the addition of one or more of several metals: cobalt, iron, chromium, silver, aluminum or zinc, but the added metals must not exceed 30% by weight of the solder. A mixture of borax and boric acid is a good flux. For soldering carbon alloy steels a flux contains metals and metalloid acids, the basic material of which will alloy with iron. Titanium dioxide, phosphomolybdic acid and aluminum molybdate in combination with a ground powder of suitable viscosity and surface tension at the soldering temperature. A suitable copper alloy may be used as a soldering metal. The fluxing mixture is: 45% alkaline borate, 25% alkali carbonate, 25% chloride and 5% titanium hydroxide. WHB

Welding and Cutting

The Welding of Ferrous and Non-Ferrous Metals by the Atomic Hydrogen Flame. R. A. WEINMAN. *General Electric Review*, Oct. 1929, pages 532–537.

In the atomic-hydrogen flame, no combustion takes place, the action in effect being a chemical transmission of heat from a source to the place where it is to be utilized. The combustion taking place when the molecules of hydrogen come into contact with the surrounding air is an envelope of burning gas of secondary importance. Means of application to metals of high and low melting points are pointed out and microphotographs are shown of various types of metals deposited on other metals. The complete atomic-hydrogen welding equipment consists of: (1) one or two insulating transformers for changing the voltage of an a. c. supply circuit to that required for welding; (2) a control panel mounting a current-controlling reactor, an ammeter, a series relay, a time-limit relay, and auxiliary contactor, a current-selecting plug switch, or a "start and stop" push-button station; (3) a combined electrode holder and torch; (4) a supply of tungsten wire electrodes for welding thin materials using currents not over 35 amps. 1/16 in. diam. electrodes are employed. For currents over 35 amps. 1/8 in. or 3/16 in. diam. electrodes are used; and (5) a welder's helmet. The operation is outlined. WHB

Strength of Welded Joints and Vessels. 1928 Technical Report of the British Engine Boiler and Electrical Insurance Co., Ltd. *Electrician*, Sept. 20, 1929, pages 325–326.

An abstract. Attention is directed to results of an investigation into the use of welding for air- or gas-pressure vessels. Accidents are largely due to welding operations being conducted in an intolerable manner. A table shows the efficiencies of some of the principal joints. The most necessary properties for metallic electrodes used for welding pressure vessels are: (1) the electrode should contain no more than 0.03% phosphorus, 0.05% sulphur, and not less than 0.50% manganese; (2) the rod should have a covering with strong deoxidizing properties and that will react chemically with the mill scale and rust on the plate, causing formation of a slag that protects the surface of the weld from exposure to the atmosphere; (3) the covering should melt at or below 1000° C. to keep the operating current low; (4) the slag should have a coefficient of contraction greater than that of the metal permitting easy removal; (5) the electrode should be protected against rusting, either by covering or other means; (6) the covering should withstand temperature changes and usual rigors of service, without cracking; and (7) the electrode should deposit weld metal free from porosity and high in ductility. Additional properties necessary to meet special conditions of service are noted and the conclusion is drawn that the ordinary commercial weld falls far short of the ideal. WHB

Thermit Welding and the Steel Mill. J. H. DEPPELER. *Advance Paper, American Iron & Steel Institute*, Oct. 1929, 32 pages.

Profusely illustrated paper showing applications of thermit welding in the steel mill and for ship repairs. Points out that by using a mixture of iron oxide and of the oxide of the desired alloying element, alloy steel welds can be produced and the weld given as good properties as the parent metal. In distinction from some other methods of welding, the molten metal freezes from the inside out, which makes for soundness. For this reason J. W. Owens, in discussion, thought thermit welding might find a place in welding pressure vessels. D. Arnot and L. F. Harper, while agreeing that thermit welds were very useful and generally dependable, pointed out the necessity of making the welds so that the welded parts are free to move during welding and cooling so as to prevent internal stress. Releasing of clamps or jacks at the proper moment, mounting on rollers, thorough preheating in a reducing atmosphere and slow cooling, sometimes with final annealing, were mentioned as most important. Welding of alloy steel parts onto carbon steel for new construction as well as repair was stated to be more economical than making all of a very heavy part of alloy steel. HWG

Modern Electric Fusion Welding. (Neuzeitliche Elektroschmelzschweissverfahren.) H. KORSINSKY. *Werksstattstechnik*, Oct. 15, 1929, pages 592–593

The article emphasizes the necessity of using coated electrodes to eliminate failures. These coatings form neutral gases, which surround the arc, thus hindering the solution of oxygen or nitrogen. To produce a direct gas protection Methanol is especially suited. Welding with atomic hydrogen is most advanced in America. GN

Copper and High Copper Alloy Welding. IRA T. HOOK. *Brass World*, Oct. 1929, pages 242–243.

An abstract of a paper read before the American Welding Society, Cleveland, Ohio, Sept. 1929. An oxygen-free copper is best obtained by remelting electrolytic copper and adding a deoxidizer in amounts sufficient to react with all of the oxygen, and for welding an excess of the deoxidizer is often advantageous. Where the electrical conductivity is a requirement care must be exercised with the deoxidant. Experimental results indicate: (1) electrolytic copper may be welded with the oxy-acetylene torch, the carbon arc, or the metal arc; (2) the provision of increased contact area for development of the full strength of the base metal may be done with the "shear V," and "wide angle," or the reinforced weld; (3) a resistance butt weld seems to develop nearly full strength; (4) Tobin or manganese bronze are preferable where a high-zinc mixture is permissible. Silicon-manganese-copper makes the best welding rod, where the arc is used; (5) tensile tests indicate that the oxy-acetylene torch or the carbon arc are more reliable in producing welds free of blow holes than is the metal arc. Results on deoxidized copper indicate: (1) the phosphorus deoxidized, the silicon deoxidized and the silico-manganese deoxidized coppers are welded with equal facility; (2) into a given welding rod, the full strength of the deoxidized copper can be developed without resorting to a reinforcing bead; (3) the highest strength of joint is developed using a high-zinc yellow bronze; and (4) the oxy-acetylene torch and the carbon arc both given good welds. A welding rod containing 3% silicon, 1% manganese and the remainder copper may be applied without fusion of the base metal. Careful supervision of men, material methods and inspection are necessary. WHB

WORKING OF METALS AND ALLOYS

Extruding

Flow of Plastic Substances Through an Opening Concentric with the Bottom of a Cylinder. (Eculement des matieres plastiques coules hors d'un cylindre par un orifice concentrique menage dans le fond du cylindre.) HERMAN UNCKEL, TRANS. BY A. SCHUBERT. *Revue de Metallurgie*, Sept. 1929, pages 503–516.

Using a plastic mass composed of differently colored strips of wax it was demonstrated that the pressure applied to the piston of the compression cylinder or the variations of the speed of its application between 3 and 120 mm./min. do not affect the relative position of the component strips. The motion parallel with the walls of the cylinder does not influence the original arrangement. All deformation takes place directly above the orifice approaching it with the decrease of the ratio between areas of the orifice and the bottom. The shape of the former has but little influence. Substituting wax with layers of 58–42 brass separated by the sheets of copper and with layers of 99.5% Al separated by sheets of Al-1%Cu heated respectively to 650 and 420° it was demonstrated that in case of metals a strong deformation takes place during the motion along the cylinder. The maximum speed of flow occurs above the orifice and the minimum at the walls. The motion of the individual particles follow the trajectories converging at the orifice. In plastic bodies they are parallel lines. The diameter of the extruded rod after proper corrections for temperature changes was always smaller than the diameter of the orifice. A mathematical presentation of the flow phenomena is given. JBG

Pickling

Pickling. (Ueber das Beizen.) K. TAUSSIG. *Archiv für Eisenhüttenwesen*, Oct. 1929, pages 253–266.

An extensive laboratory and plant investigation on quantity and type of most suitable inhibitors is described. Influence of this inhibitor on time of pickling and brittleness of the product is discussed. Also, the determination of the most suitable acid concentration and best temperature. CK

Melting and Refining

Electric Melting Improves Cast Iron. G. L. SIMPSON. *Electrical World*, Nov. 16, 1929, page 986.

Excerpts from an address. Any desired alloy may be added easily, the electric furnace provides the superheat that is distinctly beneficial to gray iron. Low carbon of high tensile strength and improved wearing qualities can be made and it is unnecessary to restrict the use of scrap metal. Electric melting permits a more intimate mixture of carbon with the iron and on cooling the carbon separates into more finely divided particles. The electric furnace iron shows higher quality in physical testing. WHB

Recent Progress in the Metallurgy of Quicksilver. W. G. ADAMSON. *Engineering & Mining Journal*, Sept. 28, 1929, pages 503–505, 508.

Mining of ore and process for production of quicksilver described. MBR

A Study of Basic Open-Hearth Slag by Solidification Tests. E. J. JANITZKY. *Advance Paper, American Iron & Steel Institute*, Oct. 1929, 18 pages.

It is an axiom in steel-making that if the slag is right the steel is too. By casting slag samples in 3 in. diam. × 1/2 in. buttons and observing color, luster, surface, convexity or concavity and fracture, it appears that the eye can recognize features that will differentiate different slags, much as a mineralogist recognizes minerals on sight. Slags from 25 heats were so studied and the appearance correlated with the composition, by plotting on triangular diagrams. Slags were taken from heats whose carbon content at time of sampling ran from 0.04–0.18% C. Correlation with the properties of the steel has not yet been carried out, but it appears that much can be told about the FeO content of the slag and hence of the steel. Photographs and plots show that definite visual slag characteristics relate to definite fields of composition. However, the standardization of the slag test will probably have to be carried out for each plant as it will probably be affected by analysis of the charge and by the fluxes used. The paper is designed to provoke thought rather than to offer a finished control method. In discussion C. H. Herty, Jr., pointed out some necessary precautions in the calculation and plotting of the slag compositions and suggested that the proper slags for a carbon content of 0.04% and for one of 0.18% C would not be the same, so that a separate standardization would be required for different carbon ranges. Nor would the proper slag for a killed steel be a proper one for a rimming steel. HWG

On the Change of Density and Electrical Conductivity of Copper during Poling. (Ueber die Änderung der Dichtes und der elektrischen Leitfähigkeit von Kupfer während des Polens.) P. SIEBE. *Metall und Erz*, Aug. 1929, pages 397–400.

Saving of samples, density in various stages of poling operation and electrical conductivity during progressive refining work are considered. EF

Recovering Silver from Scrap Material and Preparing the Metal for the Trade. F. A. Collins. *Engineering & Mining Journal*, Aug. 3, 1929, pages 164–166.

The production of silver is briefly covered and recovery from waste material described. Storage and shipping of the silver is mentioned. MBR

Recovery of Waste from Tin Base Babbitting Operation. P. J. Potter. *Technical Publication* No. 236, *American Institute of Mining and Metallurgical Engineers*, 5 pages.

Ten grades of scrap and procedure for each grade are described. EF

Utilization of Secondary Metals in the Red Brass Foundry. H. M. St. John. *Technical Publication* No. 242, *American Institute of Mining and Metallurgical Engineers*, 10 pages.

The author discusses the selection of the available scrap of Cu, Pb and Zn extensively used by red brass foundries, the selection and treatment of turnings and borings, utilization of castings and wrought metal, treatment of light and small scrap, ingot making in the foundry and refining in the electric furnace. EF

Casting and Solidification

Crystallization and Segregation Phenomena in 1.10% Carbon Steel Ingots of Smaller Sizes. Axel Hultgren. *Paper before Iron and Steel Institute*, Sept. 1929, 45 pages.

This paper gives the results of an investigation at the Soderfors Steel Works in Sweden. The paper deals mainly with 1.10% carbon steel ingots. It was found that the smaller surface crystals of random orientation forming the first solidified skin develop mainly into elongated crystals which during growth form systems of parallel, partly disconnected, slender cruciform stems. Each crystal, if not deformed, retains the direction fixed during its early growth. The interior of the ingot usually crystallizes from independent nuclei, free crystals being formed. This form of crystallization accounts for the large grained dendritic structure obtained. The cause of the segregation is also discussed in a general way, and the importance of the relative movement between liquid and solid is emphasized. Three special types of segregation are recognized and suggestions are made as to their causes. The ingot structure in certain steels which solidify as delta iron is modified when the transformation to austenite takes place; the transformed structure frequently consists of elongated grains, whose shape is partly influenced by the conditions of cooling of the ingot. The author also discusses the effect of variations in the taper of the ingot on the segregates and describes a new form of ingot mold in which the taper is principally confined to the middle portion, ends being nearly parallel. AEH

The Centrifugal Casting of Metals. (Der Metallschleuderguss.) M. von Schwarz & A. Vath. *Metallwirtschaft*, Sept. 13, 1929, pages 891–899.

A survey of the development of centrifugal casting of metals is given and the problems connected with the technique are discussed. By means of numerous investigations, soundness and fine-grained texture due to large velocities of cooling down of the mold are demonstrated. Unsoundness of the interior zones due to slag inclusions and blow-holes are discussed. The question of segregation is investigated in centrifugally cast pipes of brass and bronze. EF

Drawing and Stamping

Power Required for Deep Drawing and Deep Drawing Test Methods. (Ueber den Kraftverlauf beim Tiefziehen und bei der Tiefungsprüfung.) E. Siebel. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 9 (Report 126), pages 139–153.

The power consumption during deep drawing is investigated. The theoretical principles of deep drawing are given. In numerous tests the efficiency of deformation, as the relation between theoretical and consumed power, is confirmed. A deep draw apparatus, System Guillery, was applied to determine the power consumed drawing steel sheets of various composition (0.05 and 0.39% carbon) and thickness (0.5, 1 and 2 mm.) From the resulting power-curves theoretical diagrams are derived. The efficiency of deformation was 50–57% with the 0.05 carbon steel and 60–64% with the 0.39 carbon steel. The losses in energy of the deep drawing process are discussed. Furthermore investigations on the power necessary in the deep-draw testers were carried on. The given power-depth curves tend to show that remarkable information on the physical properties will be obtained by this new method. The determination of the Brown hardness factor, which can easily be obtained with a deep draw apparatus, seems to give information on the tensile strength within certain limits. GN

Cold Working

The Plastic Deformation of Metals. (Die bildsame Verformung der Metallischen Werkstoffe.) L. Weiss. *Metallwirtschaft*, Aug. 23, 1929, page 819–822.

The paper deals with cold working (1) by pure elongation (2) under stress (Fliessdruck) limited by skin strength (Hautfestigkeit) and (3) stress limited by strain hardening. The author supports his theoretical statements by several practical examples. EF

CHEMICAL ANALYSIS

Electrolytic Board for the Determination of Lead. O. W. Holmes & D. P. Morgan. *Industrial and Engineering Chemistry, Analytical Edition*, Oct. 15, 1929, pages 210–212.

The apparatus is a modification of the Guess-Haultain cabinet and is designed to speed up the electrolytic determination of lead in low-grade mill tailings. Twenty-four lead or 24 copper, or 12 lead and 12 copper determinations may be made at one time. Details of the method are given. MEH

Determination of Copper by 5.7-Bromine-o-Oxychinoline. (Ueber Kupferbestimmung mit 5.7 Brom-o-Oxychinolin.) *Zeitschrift für Analytische Chemie*, April 10, 1929, pages 113–124.

This method was developed with the view of determining the contents of copper in drinking water which has been treated with copper sulphate to kill plant life in the water (algae, etc.). The production of 5.7 Bromine-O-Oxychinoline is described and the condition for a precipitation of copper for a quantitative determination tested and discussed. The method can also be applied for strongly impure solutions, i. e. sewage waters. Ha

Contribution to the Determination of Calcium and Magnesium in Aluminum, with Simultaneous Presence of Si, Fe, Cu, Zn, Pb, Mn, Ti. (Beitrag zur Bestimmung von Kalzium und Magnezium im Aluminium bei gleich zeitiger Anwesenheit von Si, Fe, Cu, Zn, Pb, Mn, Ti.) K. Steinhaeuser. *Zeitschrift für Analytische Chemie*, April 10, 1929, pages 181–188.

The usual methods for the determination of Ca and Mg in Al are discussed and compared and a new way is described for separation of Mn from Mg. Ha

The Determination of Strontium and Barium. (Ueber die Bestimmung des Strontiums und Bariums.) L. Szebelledy. *Zeitschrift für Analytische Chemie*, April 10, 1929, pages 198–206.

The two metals are separated by means of isobutyl-alcohol in a similar way as used for the separation of Ka and Na. Methods and tests are fully described and discussed. Ha

A Simple Method to Distinguish Steels with and without Copper Content. (Ein einfaches Verfahren zur Unterscheidung von gekupfertem und ungekupfertem Stahl.) K. Daeves & G. Tichy. *Stahl und Eisen*, Sept. 19 1929, page 1379.

To avoid the confusion of copper and non-copper steel which are sometimes applied in the same construction, the authors developed a simple rough method to distinguish the materials. They discovered that, in pickling both steels, the copper steel became covered with stains or a fine coating of copper. Plain carbon steels or steels with a content up to 0.12% Cu showed the silver shining iron color, whereas steels with over 0.20% Cu were covered with the mentioned copper stains. The copper sediment was developed fairly well, if, before pickling, the material was annealed for a short time from 800–900° C. in an oxidizing atmosphere. GN

Estimating Iron in Chromium Alloys. *Electrician*, Oct. 11, 1929, page 428.

The method is based on the oxidation of chromium by ammonium persulphate and then precipitation of the iron with ammonia. A 1–3 gram sample is dissolved in acid—dilute sulphuric where possible and hydrochloric or aqua regia, if necessary followed by addition of sulphuric acid and fuming. The solution is diluted with hot water and boiled, the silicon removed, if present, and the solution cooled and diluted to 250 cc. and an aliquot containing 0.1–0.2 grams of iron used. This portion is diluted to about 150 cc., 2 grams of persulphate added and the iron determined as ferric oxide. Nickel may be determined by the dimethylglyoxime process in the filtrate. WHB

Determination of Oxygen in Steel by the Hot-Extraction Method. (Beitrag zu der Bestimmung des Sauerstoffs im Stahl nach dem Heissextraktionsverfahren.) G. Thanheiser & C. A. Mueller. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 5 (Report 122), pages 87–94.

The paper gives the results of previous investigations and describes the method applied. Reduction tests with various metal oxides show that only Fe_2O_3 and MnO are completely reduced. SiO_2 and Al_2O_3 are not completely reduced up to 1500° C. A reduction temperature above 1500° C. is not advisable. Oxygen analyses with a steel resulted in large differences (0.012–0.033%) which are partly due to the evaporation of manganese. The best results are obtained when each specimen to be extracted is examined by itself. GN

On Simple Methods of Potentiometric Titration of Acids and Bases. L. Kahlenberg & A. C. Krueger. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 75–85.

The traditional calomel electrode may be dispensed with. Using tungsten as one of the electrodes, a large number of other metals served as the other electrode. Equilibrium is reached most rapidly with the couples W-Cu, W-Si W-Ni and W-Co which all exhibit an actual change in polarity at the neutral point. EF

On the Determination of Manganese in Steel According to Wald. (Ueber die Mangan-bestimmung in Stahl nach Wald.) J. Kassler. *Chemiker Zeitung*, Sept 14, 1929, page 719.

Modification of method for determination of Mn in steel is given. EF

Recent Developments in the Analysis of Carbon in Iron and Iron Alloys. N. A. Ziegler. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 1–8.

The error of the "Yensen" method, consisting in converting all carbon at 1050° C. in the vacuum by means of pure oxygen into CO_2 and freezing it out in liquid air, has been reduced from ±0.0005% down to ±0.0001% by described modifications and precautions. EF

HISTORICAL AND BIOGRAPHICAL

Iron in Antiquity. T. A. Rickard. *Paper before Iron and Steel Institute*, Sept., 1929, 19 pages.

The author reviews the early history of Iron, dealing chiefly with the Egyptians and peoples of the pre-Christian era. AEH

PLANTS AND LABORATORIES

The New Plant of Friedr. Krupp A.-G. in Essen-Borbeck. I. Blast Furnace Plant (Das Hüttenwerk der Firma Friedr. Krupp A.-G. in Essen-Borbeck. I. Das Hochofenwerk). *Stahl und Eisen*, Oct. 24, 1929, pages 1541–1550; *Krupp'sche Monatshefte*, Oct. 1929, pages 139–159.

The article describes origin and location of the plant, and gives detailed information on supply of raw materials, ore stock yards, ore and coke bunkers, two blast furnaces with 600 and 400 tons daily output, gas cleaning plant, gas distribution including recording instruments, utilization of slag, and power plant with steam turbines. GN

Electric Annealing Plants (Elektrische Glühanlagen). Th. Stassinet *Stahl und Eisen*, Oct. 17, 1929, pages 1509–1518.

Report No. 70 of the rolling mill committee of the Verein deutscher Eisenhüttenleute. The results of examination of an electric hydrogen-bright annealing plant and of an electric black annealing plant are given. Equipment and operation of both plants are described. Tables show capacity and current consumption. Bright and black annealing furnaces are compared. Rules for an economic application of electric annealing furnaces are outlined. In which cases an electric annealing operation is preferred to coal or gas fired pot annealing furnaces is discussed. GN

Heat Treatment of Alloy Steels in Airplane Works. C. B. Phillips. *Aviation*, Oct. 19, 1929, pages 781–783.

Heat treatment of the standard airplane steels: Cr-Mo, low carbon, Ni, Ni-Cr, (case hardening), and low and high carbon Cr-Va steels as well as the equipment in the Fairchild Factory are given. EF

Research Laboratory for the Cold-working of Steel at Sheffield University. *Journal Society of Chemical Industry*, Aug. 2, 1929, page 767.

A brief description of a new laboratory for steel-working research opened on July 6, 1929.

DEFECTS

Season-Cracking of Metals. I. V. Williams. *Bell Laboratories Record*, Oct. 1929, pages 77–79.

This article describes a case of season cracking in an aluminum bronze ratchet wheel. Factors causing this failure: tension stress in outer surface of material and accompanying corrosion. It has been found to occur in parts produced by spinning, drawing, pressing or rolling. Methods for prevention are mentioned.

The Causes of Cuppy Wire. W. E. Remmers. *Technical Publication* No. 237, *American Institute of Mining and Metallurgical Engineers*, 12 pages.

Investigations were carried out to clarify the defect in wires known as "cuppiness." Among the various conditions studied were straight sided and curved die contours, amount of reduction per die, the effect of a lubricant, relieved dies and oxygen content of the copper. EF

Failures of Steam Boiler Elements. (Schadenfälle an Dampfkesselelementen.) A. Pomp & P. Bardenheuer. *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, 1929, Vol. 11, No. 11 (Report 128), pages 185–191.

Three cases of boiler failures were examined. In two cases the observed cracks are due to the influence of aging effects on material stressed above the yield point, and in the third case the failure must be contributed to corrosion attack. GN

The Location of Segregations in an Ingot after Freezing. (Sur la configuration de la segrégation des lingots après solidification.) GEORGES D'HUART. *Revue de Metallurgie*, Oct. 1929, pages 532–537.

The outer very thin layer of steel chills in almost an amorphous state. This is followed by the growth of dendritic crystals towards the center. Sulphur compounds rise upwards but are caught on projecting dendrites. At the beginning of the formation of equiaxial crystals the liquid core of the ingot is at almost freezing temperature at which the grains of pure iron begin to precipitate and to settle down while sulphides are still rising up which results in an area of greater purity than the body of the ingot surrounded by sulphide inclusions. The distribution of the segregations is dependent on the speed of relative motions of sulphides upward and dendritic crystals in horizontal, or more accurately, in a direction perpendicular to the walls of the ingot mold. As the first is much higher than the second the outside segregation zone forms a pyramid converging upwards independently of whether a big end up or big end down mold is used. In the latter stages of solidification when freezing from the bottom is well felt the deficiency of the metal due to contraction is supplied from highly segregated metal from the upper part of the ingot or from the hot top resulting in central V shaped inclusions. Sulphur prints and iodine etchings of split 8.4 ton ingots given in the paper support this viewpoint. JDG

Relieving Casting Strains. *Oxy-Acetylene Tips*, Nov. 1929, pages 88–89.

An unusual method of relieving casting strains is given and the process of welding cracks due to internal stress is discussed. MLM

On Reversed Ingot Segregation of Duralumin. (Zur umgekehrten Blocksseigerung beim Duralumin.) S. M. WORNONOFF. *Zeitschrift für Metallkunde*, Sept. 1929, pages 310–316.

A reverse segregation as observed on casting pure Al (99–99.5% Al) and some of its alloys in molds, is due to the formation of solid solutions within a larger range of temperature, resulting in a change of the initial segregated crystals, in comparison with the remaining melt. The compression during solidification plays the main role in this phenomenon. Since the segregation in the exterior zones of the ingot causes defects in the rolled material, the author recommends (a) reduction in percentage of element, which are responsible for the reversed segregation thus approaching solidification temperature of segregation, solid solution and melt, (b) lowering of differences in solidification between center and outer parts of ingot by preheating the ingot, (c) careful removal of all visible parts showing reversed segregation to overcome these defects. The paper includes 13 illustrations and 14 tables. EF

FURNACES AND FUELS

Controlling the Atmosphere in Malleable Annealing Ovens. W. F. GRAHAM. *Preprint* 29–14, *American Foundrymen's Association*, pages 295–304.

As the atmosphere in annealing furnaces has a considerable influence on the decarburization of the metal surface, controlling the atmosphere is most important. The presentation of results is confined to a description of apparatus design, the method of firing ovens with powdered coal. GN

Progress in Alloys of Iron Research. F. M. WALTERS. *Mining & Metallurgy*, Sept. 1929, pages 418–419.

A new laboratory furnace for making alloys the constituents of which have a high vapor pressure and thus forbid the use of a vacuum, is described in detail. The application of nitrogen, hydrogen, helium and argon as inert gas media is critically discussed and the reasons for the selection of argon are given. EF

Dimensions and Capacity of Electric Arc Furnaces (Masse und Leistung der elektrischen Lichtbogenoefen). DR. KALPERS. *Dinglers Polytechnisches Journal*, Sept. 1929, pages 178–182.

The author gives an extract of a report concerning the results of an inquiry of the Elektroausschuss des Vereins deutscher Giessereifachleute, Berlin 1929, concerning the dimensions, electric installations, melting times and output, efficiency, influence of charged material and various other experiences in melting practice. EF

The Design and Operation of Vacuum Furnaces with Carbon Resistor Tubes. A. S. KING. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 47–60.

Two types of electric vacuum resistance furnaces are developed with the object of studying metallic vapors spectroscopically. The cylindrical as well as the hooded type of graphite resistor-tube furnace has a temperature range up to 3500° C. and give steady conditions of temperature and pressure within a short time. EF

ECONOMIC

World Development in Electrolytic Zinc. A. ZENTNER. *Mining & Metallurgy*, Nov. 1929, pages 526–531.

The paper presented before the San Francisco Section, Sept. 1929, outlines the development in electrolytic zinc in the different countries, compares the competitive processes and discusses marketing possibilities. VSP

Thirty-seventh Annual Report of the Ontario Department of Mines. Vol. XXXVII, Part I, 1928, 215 pages.

The report gives a statistical review of Ontario's Mineral Industry in 1927, with numerous tables showing the production of gold, silver, cobalt, nickel, copper, platinum, lead and zinc as well as the non-metallic minerals. It gives a review of the classes for prospectors for 1927–28. A large section of the report is devoted to a description of the mines and metallurgical plants of the province. It also gives the mining accidents in 1927. MLM

Secondary Metals in 1927. J. P. DUNLOP. *Bureau of Mines, Mineral Resources of the United States*, 1927, Part I, pages 373–392.

This report gives a classification of old metals and a review of their recovery in 1927. Figures are given for the recovery of copper, lead, zinc, tin, antimony, aluminum and nickel. MLM

Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1927. Mine report by CHAS. W. HENDERSON. *Bureau of Mines, Mineral Resources of the United States*, Part I, pages 455–479.

The report gives a survey of the mining and metallurgical industries with tables showing the mining, production and ore classification. A review by counties is given for New Mexico and, in briefer form, for Texas. MLM

Zinc in 1927. ELMER W. PEHRSON. *Bureau of Mines, Mineral Resources of the United States*, Part I, pages 479–507.

An intensive survey of the zinc industry in the United States is given, with figures and tables showing the production of zinc and recovery of secondary zinc. Figures for world production and consumption are given. MLM

Rare Metals: Cobalt, Molybdenum, Nickel, Tantalum, Titanium, Tungsten, Radium, Uranium and Vanadium in 1927. FRANK L. HESS. *Bureau of Mines, Mineral Resources of the United States*, Part I, pages 393–453.

This pamphlet gives a thorough review of the rare metals with tables showing their consumption and production. Bibliographies are also given. MLM

Mineral Production of Ontario. First Six Months 1929. *Bulletin* No. 69, *Ontario Department of Mines*, Aug. 1929, 8 pages.

Reports on mineral production received by the Ontario Department of Mines from the mines, smelters and refining works of the Province for the six months ending June 30, 1929 are given. Comparative figures are given for the corresponding period in 1928. MLM

World's Consumption of Calcium Carbide. (Le consommation mondial du carbure de calcium.) *Journal du four electrique*, Sept. 1929, pages 294–295.

A brief outline of the world consumption of calcium carbide. JBG

Export Trade in Electric Furnace Products Made in France. (Commerce exterieur des produits du four electrique en France.) *Journal du four electrique*, Sept. 1929, pages 297–298.

A summation of export figures of materials made in French electric furnaces. JBG

Preliminary Report on the Mineral Production of Ontario in 1928. *Bulletin* No. 68, *Ontario's Department of Mines*, 1929, 32 pages.

This is an advance statement dealing with the mineral production of the Province of Ontario for the year 1928. For purposes of comparison final figures for 1927 are given. The report covers the output of mines, quarries, clay and gravel pits, also the products of metallurgical plants treating Ontario ores and minerals. These statistics will be embodied in the Thirty-eighth Annual Report of the Ontario Department of Mines. MLM

MACHINERY AND SUPPLIES

Plant Equipment

Nickel Coated Pots Show Longer Life. G R. GREENSLADE. *Iron Trade Review*, Aug. 15, 1929, pages 387–388.

From "Inco," house organ of the International Nickel Co. Containers for lead, salt, cyanide or caustic baths are made of pressed low-carbon steel or ingot iron, coated on the outside with a thick non-oxidizing layer of nickel. The latter is applied by arc welding. The nickel-coated steel has more than three times as high a thermal conductivity as a 20% chromium alloy steel. The new pots have lasted over 7000 hours under severe service. MS

FOUNDRY PRACTICE AND APPLIANCES

Practical Aspects of White-Fracture Malleable. D. P. FORBES. *Preprint* 29–22, *American Foundrymen's Association*, pages 397–404.

The paper describes the meaning of white-fracture malleable, explains why and under which conditions white fracture occurs, suggests how its appearance can be avoided or corrected, and offers a possible metallurgical explanation of the phenomenon. GN

Application of Malleable-Scrap; Nickel and Chromium in Gray Cast Iron Foundries. (Die verwendung von Temperschrott, Nickel und Chrom in der Graugesserei.) M. APFELBÖCK. *Zentral-Europäische Giesserei-Zeitung*, May 1929, pages 5–6.

Temper-scrap requires more coke due to its higher melting temperature. Rusty temper-scrap should not be charged. By additions of 10–15% of temper-scrap in cupola charges a substantial improvement of cast iron properties can be secured. Nowadays the addition of Ni, or in combination with Cr, becomes more and more important. Some compositions of cast iron containing Ni and Cr are given. EF

Principles of Casting of Non-Ferrous Metals in Dry and Wet Sand. (Leitgedanken über das Geissen von Nichteisenmetallen im trocknen und nassen Sand.) M. WEISS. *Zentral-Europäische Giesserei-Zeitung*, May 1929, pages 3–4.

The author discusses questions concerning the dressing of wet molding sand, phenomena during casting of metals in dried and pre-heated molds and precautions during making the molds. EF

The Fight Against the Cast Skin. (Der Kampf gegen die Gusshaut.) O. G. STYRIE. *Zentral-Europäische Giesserei-Zeitung*, May 1929, pages 9–10.

For destruction of the silica-layer and its softening, tumbling, sand blasting and pickling are applied. Tumbling and sand-blasting remove the silica skin, it is true, but do not reduce the hardness of the cast skin. The advantage of pickling consists in penetrating the pores and removing the sand particles which form the silica-skin. Another method is soft annealing. EF

REFRACTORIES AND FURNACE MATERIALS

The Electrical Conductivity of Magnesite and Some Other Refractory Materials in Relation to the Temperature and Their Other Properties. E. DIEPSCHLAG & F. WULFESTIEG. *Paper before Iron and Steel Institute*, Sept. 1929, 24 pages.

This paper gives the results of a research into the changes which take place in the electrical conductivity of magnesite used in electric furnace practice. The results obtained confirm previous experiments. With rising temperatures the resistance first falls rapidly, becoming lower at high temperatures. Owing to the impossibility of obtaining a completely homogeneous material, the mean value of several experimental results had to be taken. The curves of previously burnt and unburnt materials showed great differences owing to internal transformations taking place which influence the electrical resistance until they are completed. At every temperature, if it is maintained long enough, an internal stable resistance is reached, expressed by constant values of resistance. AEH

Report of the Joint Committee on Refractories—Subcommittee Survey of Gray Iron Foundry Refractories. *Preprint* 29–26, *American Foundrymen's Association*, pages 459–466.

The report is the result of a questionnaire sent out to some 200 selected gray iron foundries. The report is presented in great detail. GN

Attack of Fire-Proof Materials. (Angriffswirkungen auf feuerfeste Baustoffe.) M. PULFRICH. *Korrosion & Metallschutz*, Sept. 1929, pages 193–199.

This paper presented at the Reichsausschuss für Metallschutz, Berlin, 1928, discusses all kinds of refractory and fire-proof materials under all kinds of stresses as physical, chemical and mechanical. A bibliography is included. EF

GASES IN METALS

Degasification Process of Aluminum and Its Alloys in the Liquid State. (Schmelzfluss-Entgasungaverfahren für Reinaluminium und Aluminiumlegierungen.) W. CLAUS. *Zeitschrift für Metallkunde*, Aug. 1929, pages 271–273.

The previous methods of degasification are critically reviewed, those of: (1) Archbutt, based on the reversibility of solubility equilibrium and consisting of lowering the temperature below the solidification point, remelting and casting, or by passing nitrogen through the melt at solidification temperature. (2) Tullis, which is similar to (1) but uses gases more active chemically as chlorine, boron-tri-chloride, etc. The method developed by Claus-Kalaehne uses the same main principle outlined under (1) but changes, in contrast with Archbutt, the furnace gas atmosphere, which is now neutral. The author supports the successful application of physical-chemistry by investigation with the alloy "Y," the results are given in a table and checked by photomicrographs. A considerable increase of tensile strength and elongation could be secured. The author however, suggests the prevention of gas absorption by application of crucible furnaces, instead of degasification methods, two furnace types are illustrated. EF

Permeability of Metals by Gases. (Permeabilite des metaux aux gaz.) VICTOR LOMBARD. *Revue de Metallurgie*, Oct. 1929, pages 519–531.

The different methods of presenting data obtained during investigation of the permeability of metals by gases (16 bibliographic references are given) does not permit an easy comparison. The author reduced them to the same terms to verify the statements: the structure of the metal has an influence on the speed of penetration; the speed of penetration is proportional to the square root of the pressure; it is inversely proportional to the thickness of the metallic wall; there is a definite relation between the temperature and the amount of gas passing in a unit of time through a given area. The data of different investigators substantially support these statements. The formulae proposed for expressing the laws of penetration agree well among themselves inside 350–760° range but result in curves of different curvatures outside of it. Gas–metal systems studied were: N-Pd, H-soft steel, H-Fe, H-Ni (1% Co, 0.5 % Fe, .15 Si), H-Cu, H–Ni (electrolytic), H–Zn, Co-soft steel, He–Ni (1% Co, 0.5 Fe, 0.15 Si), H–Pt, Ar–Ni (1% Co, 0.5 Fe, .15 Si), N–Ni (1% Co, 0.5 Fe, 0.15 Si), O–Ag, H–Al. The series is arranged in order of decreasing permeabilities. JDG

EFFECTS OF ELEMENTS ON METALS AND ALLOYS

Effect of Manganese on Distribution of Carbon in Steel. B. M. LARSEN. *Technical Paper* No. 466, *United States Bureau of Mines*, 1929, 31 pages.

Three factors essentially determine the modifying effects of manganese on carbides in the iron–carbon system. These are (a) manganese tends to enlarge the temperature range of stability of gamma iron or austenite, (b) manganese forms a carbide that is more stable than cementite, and (c) manganese atoms can hardly diffuse at all through the iron space lattice at ordinary heat-treating temperatures at which carbon atoms diffuse freely. In steels containing more than 1% of manganese, dendritic segregation causes a marked dendritic pattern on cast sections and a fibrous pattern in rolled or forged bars. Manganese is higher in the dendrite fillings. Heat treatment up to 1100° C. is ineffective, but an hour's heating at 1300° C. causes manganese diffusion to a uniform concentration throughout. As a cast bar with 1 to 3% manganese cools through the critical range the Ar_3 point is reached first by the lower manganese axes of the dendrites. If the cooling rate is below 5 to 7° F. per minute, the carbon tends to segregate in the high-manganese fillings between the dendrites. With a total carbon content of 0.3% or less, a dendritic pattern is formed by the pearlite or sorbite areas in cast sections, and a marked banded structure in rolled or forged bars; the ferrite areas always correspond to the dendrite axes. Phosphorus and arsenic tend to cause these same patterns, but as these elements raise the Ar_3 point of pure iron, the ferrite areas formed correspond to the dendrite fillings. Above the Ar_3 point the carbon atoms are probably uniformly distributed in the gamma-iron lattice. With an increasing percentage of manganese, a manganese-cementite tends to form, perhaps containing an increasing proportion of molecules of Fe_2MnC. Up to 2% manganese, finer grained pearlite and sorbitic areas are formed. Above 2% manganese the carbides separate in a fine-grained distributed structure that may be linked together through the manganese atoms scattered through the iron space lattice. The eutectoid point of pure iron-carbon alloys at about 0.9% carbon appears to widen with an increase in the amount of manganese into an eutectoid range which with 3% of manganese extends from 0.6 to 0.92% carbon. This apparent eutectoid range is probably the result of a very small temperature interval between Ar_3 and Ar_1 points in given range of carbon content. AHE

Aluminum Bronzes Containing Manganese, Tin and Cobalt. (Etude sur les cupro aluminium au manganeze, a l'etain et au cobalt.) ERNEST MORLET. *Revue de Metallurgie*, Sept. 1929, pages 554–569.

A comprehensive study of the changes produced by substitution of a portion of aluminum in aluminum bronze with tin. JDG

A Study of Copper Aluminum Alloys Containing Manganese, Tin and Cobalt. (Etude sur les cupro-aluminium au manganese, a l'etain et au cobalt.) ERNEST MORLET. *Revue de Metallurgie*, Sept. 1929, pages 464–487.

In the present paper to be followed by the others the author studied the properties given to aluminum bronzes (Cu 84–89%, Al 6–10%) by the addition of 1–6% Mn. A very comprehensive study of physical and metallurgical characteristics is presented being well illustrated with micrographs and figures. JBG

Manganese in Cast Iron. A. L. NORBURY. *Foundry Trade Journal*, Aug. 1, 1929, pages 79–83; *La Revue de la fonderie moderne*, Sept. 10, 1929, pages 395–403.

Paper presented to the International Foundrymen's Congress. States that graphitizing action of manganese only occurs in low-manganese irons and is an indirect one due to its combining with sulphur. Traces of sulphur (e. g., 0.01 percent) are sufficient to prevent graphitization. Discusses results obtained by various authorities on graphitizing action of manganese. Phosphorus, nickel or iron do not graphitize secondary cementite. Manganese appears to be the only element which does. Contains a number of photomicrographic illustrations and discusses the action of low-manganese and traces of sulphur on cast iron. Uses of manganese in foundry practice. Contains tables and references. VSP & GN

The Influence of Use of Sponge Iron on the Properties of Steel. (Der Einfluss der Verwendung von Eisenschwamm auf die Eigenschaften von Stahl.) W. ROHLAND. *Stahl und Eisen*, Oct. 10, 1929, pages 1477–1487.

Report No. 156 of the Materials Committee of the Verein deutscher Eisenhüttenleute, presented at its 16th session, July 14, 1929. Includes discussion. To investigate the influence of sponge iron on the properties of various steels, samples were melted in an electric arc furnace or a high frequency furnace respectively. Sponge iron produced by the Norsk-Staal process was used. Soft steels with 0.01–0.05% carbon or 0.1–0.2% carbon were absolutely free from red or cold shortness had a maximum "Formaenderungsfaehigkeit." The 0.1–0.2% carbon steels with only 0.06% manganese were perfectly stable to aging effects. The improvement of the physical properties is significant, 85,000 lbs./in.^{2} tensile strength, 21% elongation, and 62% reduction of area were found in testing a 0.02% carbon steel after normalizing. Unalloyed steels with a low manganese and silicon content were tested. The excellent heat working qualities and the very fast solution of pearlite below the transformation range are significant. In quenching, these steels are very tough. The results with unalloyed tool steels with a normal manganese and silicon content are similar. They are especially insensitive to heat treatment and, in consequence of their toughness, qualified for steels subjected to continued high tension. Improvement of cutting qualities make sponge iron suitable for production of high speed steels. The reasons for the essential improvement of sponge iron steels can only be found in the "virginity" of the applied material. GN

Deoxidation of Copper with Calcium and Properties of Some Copper-Calcium Alloys. E. E. SCHUHMACHER, W. C. ELLIS & J. F. ECKEL. *Technical Publication* No. 240, *American Institute of Mining and Metallurgical Engineers*, 13 pages.

Small additions of Ca deoxidize Cu without materially impairing electrical conductivity and mechanical properties. The oxygen content should be known approximately, so that use of Ca is cut down to minimum. EF

MISCELLANEOUS

Salvaging Scrap Cable. *Electrical World*, Sept. 21, 1929, page 560.

Three common methods are used: sale based upon analysis, mechanical separation and separation by furnace. Copper from cable may be easily baled. Lead should be cast into pigs. It is well to separate the seals on the ends of the cable joints on account of the tin content. One user found it best to accumulate all the scrapped cable joints and run them in separate lots through the scrap furnace. The lead and solder is run off and the resulting mixture is segregated from the ordinary lead on account of its greater value. The conductors with their sleeves are pulled out of the fire before they get too hot and the sleeves are melted off by dipping in a pot of hot lead. WHB

Lime Process for Coating Aluminum. L. MCCULLOCH. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 195–197; *Canadian Chemistry and Metallurgy*, Oct. 1929, page 271.

A dead-white coating is produced upon aluminum by boiling the article in "milk of lime" with the addition of a little calcium sulphate. The bath should be close to boiling temperature and gently stirred. The coating analyzed: Al_2O_3 53.7%, $CaSO_4$ 14.0%, $Al_2(SO_4)_3$ 3.3% and water 29.0%. $CaSO_4$ tends to make a smoother surface, fine-grained and adherent. Upon aluminum the coatings are dead white and upon alloys of aluminum they are various shades of gray. The coatings are not especially resistant to corrosion, but applied to sheet aluminum and coated with size might be written and printed upon, and prove useful for instrument scales and dials. They form excellent foundation for paints and enamels. WHB & EF

The Tool Metal "Widia" (Das Werkzeugmetall "Widia"). *Krupp'sche Monatshefte*, Oct. 1929, pages 160–172.

Summarized report of a paper by A. Hofmann "'Das deutsche Werkzeugmetall,' 'Widia' und das amerikanische 'Carballoy'" in *Werkzeugmachine* April 30, 1929. The historical development of cutting metals is outlined, the production of "Widia" is described, the preparatory work before it can be put in operation is emphasized, the field of application is given. The supremacy of tungsten carbide in comparison with high speed steels can be seen from the diagrams given. The precautions for a successful application are discussed. The cutting angle is most important, depending on the machined material. Cutting with a red hot edge destroys the metal by oxidation. GN

A Study of Fatigue Cracks in Car Axles. Part II. H. F. MOORE, S. W. LYON & N. J. ALLEMAN. University of Illinois, *Bulletin* 27, No. 11, Nov. 12, 1929. *Bulletin* No. 197, *Engineering Experiment Station*. (Cooperative work for the Utilities Research Commission.)

A study of the reclaiming of cracked car axles. If smaller sized axles are turned out from cracked ones, and the material is removed at least 1/16" below the last visible trace of the crack, the core material remaining is serviceable. Invisible cracks extend beyond the visible ones so that if turning off does not go below what looks like sound metal, the reclaimed axle is not undamaged. This was established by endurance tests on ordinary small specimens and on specimens of 1" and 2" diameter. HWG

Manufacture of Wire Bars from Secondary Copper. W. A. SCHEUCH & J. W. SCOTT. *Technical Publication* No. 246, *American Institute of Mining and Metallurgical Engineers*, 16 pages.

The work of 4 years reported in this paper proves that wire bars of present commercial electrolytic quality can be made by converting secondary copper in a suitable reverberatory furnace. The problem is fully outlined from a metallurgical and economical viewpoint. EF

The Hardening of Superhardened Steel by Magnetism. EDWARD G. HERBERT. *Paper before Iron & Steel Institute*, Sept. 1929, 17 pages.

This paper discusses the increased hardness produced in work hardened metals by annealing at certain critical temperatures and describes experiments on the magnetic treatment of work hardened materials with a view to the production of a similar effect. The conclusion is drawn that low temperature annealing and magnetic treatment appear to be strictly alternative processes, producing the same atomic rearrangement and increase in hardness. The magnetic treatment described was applied to a variety of ferrous and non-ferrous materials, including Invar, stainless steel containing nickel 10.5, chromium 15.1% and case-hardened nickel steel. In every case the increase in hardness anticipated from the above considerations was found to have taken place. Specimens which had been magnetically hardened underwent no further increase in hardness when subjected to annealing at temperatures which would bring about hardening in work-hardened samples which had not been magnetically treated. The author discusses observed facts in relation to lattice resonance theory. AEH

Waste Prevention and Salvage as Applied to the Steel Industry. F PARRISH. *Advance Paper, Iron & Steel Institute*, Oct. 1929, 19 pages.

Details of a waste prevention campaign. Problems of salvage, obsolescence, depreciation, cost of carrying obsolete or spare material on inventory are discussed. Simplification and elimination of waste through it are advocated. HWG

Cobalt-Oxides and Their Systems with Oxygen (Untersuchungen über Kobaltoxyde und deren Systeme mit Sauerstoff). M. LE BLANC & E. MÖBIUS. *Zeitschrift für physikalische Chemie*, June 1929, Abt. A, pages 151–176.

Cobalt-oxide produced in vacuo at low temperature can occlude oxygen without showing a lattice conversion. At first the unstable system CoO–NO_2 is formed which is transformed by heating into the stable compound Co_3O_4. This latter compound can also take up oxygen without lattice conversion. Co_2O_3 could, so far, not be obtained by a dry method, but by a wet method. The properties of all these systems are described in great detail and thoroughly discussed. HA

Thermo-electric Tests for Aluminum-manganese and Other Alloys. CYRIL S. TAYLOR & JUNIUS D. EDWARDS. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 157–160; *Canadian Chemistry & Metallurgy*, Oct. 1929, page 284.

Manganese has an outstanding effect upon the thermo-electric properties of Al-Mn alloys. While copper, iron or silicon up to several percent show a thermo-electric force against aluminum at the m. p. of less than 50 microvolts about 1% of manganese will show a thermal e. m. f. of over 300 microvolts under like conditons. An ordinary soldering iron, slightly modified, is used as heating device—one with a removable copper. A length of 99.4% aluminum wire is welded onto a suitable-sized rod of the same purity aluminum and the latter is threaded tightly upon the projecting end of the soldering copper. The other end of the wire is attached to one terminal of a sturdy but sensitive portable galvanometer. The aluminum rod and wire form one member and the specimen the other member of the thermocouple. The specimen is connected by clip and wire to the remaining terminal of the galvanometer. The specimen is placed upon the sheet and becomes automatically connected to the galvanometer. Sample products of known composition should be available for comparison. To make a test the heated aluminum rod (soldering rod) is touched to the specimen and the galvanometer watched for a deflection. No deflection means that the metal is pure aluminum. EF & WHB

Combustion Temperature of Sulphur, Pyrites and Galena (Verbrennungstemperatur von Schwefel, Pyrit, und Zinkblende). J. S. DOTING. *Chemiker Zeitung*, Sept. 21, 1929, pages 737–739.

New determinations in the Technische Hochschule, Delft yielded 1025, 965 and 1050° C. respectively. EF

Commercial Application of Beryllium Awaits Reduction of Production Costs

The commercial application of beryllium, a metal which has been the object of recent widespread interest, is definitely limited until such time as the cost of extraction, now almost prohibitively high, can be reduced, according to the United States Bureau of Mines, Department of Commerce. Beryllium is quoted in this country at $200.00 per pound and shipments are made chiefly from small stocks manufactured in 1927 or earlier. As in all metallurgical operations, the production of the metal on a laboratory or semi-commercial scale is much more costly than it would be in large lots. The metal could be manufactured at greatly reduced costs with the market absorbing appreciable tonnages annually.

Beryllium, or glucinum, as it is also called, is often listed as a rare element, though it probably is more abundant in the earth's crust than many of the minor metals that are ordinarily considered rather common, states Alice V. Petar, in a report just made public by the Bureau of Mines. It is not a new metal, for it has been known for more than a hundred years, but even yet it has not been put to work commercially except to an extremely limited extent. Since beryllium is very light and exceptionally hard and strong, many believe that it is destined to share with magnesium and aluminum in the fast-growing demands for light metals to be used in the construction of air craft.

The mineral beryl, which seldom contains more than about 5 percent of the element, is the only recognized ore of beryllium. It is a common accessory in pegmatite veins and is also found in clay slate and mica schist, but hitherto only the gem varieties, including emerald and aquamarine, have been actively sought. In several localities, however, ordinary beryl is produced as a by-product in mining mica and feldspar, and often beryl has accumulated on the dumps because no buyer could be found. Only within the last two or three years has there been an active demand for the mineral, even in ton lots, and as yet requests for car-load shipments are extremely rare. Considerable interest has been awakened, nevertheless, in the possibility of opening deposits that will yield beryl in substantial quantity.

The metal beryllium, or glucinum, has aroused the interest of many investigators, who have worked out various processes of extracting it from its ores. Beryllium is very light, having about the same specific gravity as magnesium, and is almost as hard as quartz. It will scratch glass and it takes a high polish. Early investigators claimed that beryllium was malleable and could be easily forged and cold-rolled into sheets, but later studies do not support these claims. While it is possible that absolutely pure beryllium, if obtained, might have the qualities formerly attributed to it, investigations conducted at the Bureau of Standards with metal of 98.7 percent purity indicated the contrary. This product was described as "coarsely crystalline, reminding one of antimony or bismuth, * * * hard and brittle, and apparently incapable of being wrought cold." It is further stated that more recently metal of more than 99.5 percent purity has been produced, some lots of which are semi-malleable cold and can be rolled hot into a thin sheet. The melting point of beryllium has been determined as 1,285° C., or a little above that of manganese.

Considerable research has been carried on in this country and abroad toward the development of uses for beryllium, but the use of the metal is still in the experimental state. From time to time there have been items printed describing it as the new and logical light metal for aviation use, and the Materials Subcommittee of the National Advisory Committee for Aeronautics is planning to arrange for tests of beryllium for use in airplane construction. Nevertheless, to date, this use has not materialized, and a German company, which has been particularly diligent in its studies of the properties and possible uses of the metal has concentrated its efforts chiefly upon alloys containing small quantities of beryllium with heavy metals, such as iron, copper and nickel.

It is claimed that beryllium hardens iron to a great extent and that alloys of beryllium with copper and nickel have high resistance properties and should find application in grinding, stamping, spring making, etc.

In the United States the metal has been produced on a semi-commercial scale by one concern. While this company has devoted some attention to the heavy alloys, chiefly those of beryllium with gold and silver, its chief interest has been with the beryllium-aluminum alloys. It has been stated that the addition of beryllium to aluminum increases its strength and resistance to corrosion, and that an alloy containing 70 percent beryllium and 30 percent aluminum exhibits materially greater resistance to salt water and air corrosion than any other of the light alloys.

Beryllium has been used in this country and abroad in X-ray apparatus. Another use which may grow considerably is for electrodes in connection with neon signs.

Experiments have been conducted at the University of Pittsburgh on over 80 different glasses in which beryllium oxide replaced calcium oxide or magnesium oxide. It was found that beryllium glasses are somewhat more refractory than magnesium or calcium glasses and that beryllium glass is much harder than calcium or magnesium glass. Results so far obtained indicate that beryllium glasses warrant further study.

Beryl, the only recognized ore of beryllium, is a compound silicate of aluminum and beryllium. In color beryl varies from white or colorless to green, blue, yellow (amber), and even red, but usually it is some shade of green. Clear transparent crystals are cut as gems. The deep green variety, the color of which is attributed to the presence of a little chromium, is the emerald which is worth more than the diamond. Aquamarine, a sky-blue or greenish-blue variety, is also a precious stone. Beryl is about as heavy as quartz, sometimes a little heavier, but its outstanding characteristic is its hardness. It is harder than quartz or tourmaline and practically as hard as topaz, from which it differs in that it has no distinct cleavage. It crystallizes in hexagonal prisms ranging in size from mere thread-like pieces to huge crystals many feet in length and weighing several tons. Occasionally it occurs in large columnar or granular masses.

In addition to its potential value as a source of beryllium metal, ordinary beryl may have other uses, notably as a substitute for feldspar in the manufacture of porcelain.

Occurrences of beryl have been noted in many states. Good emeralds have been found in Massachusetts and in North Carolina. Aquamarines and other gem specimens have been obtained at Paris and Stoneham, Me., Mount Antero, Colo., and several places in North Carolina. The best emeralds, however, are mostly imported. The world supply comes from Colombia, British India, Brazil, Siberia, Australia, and (recently) South Africa.

In recent months there has been some inquiry for beryl from abroad, and it is understood that foreign buyers have been paying in the neighborhood of $60.00 a short ton f. o. b. New York. However, there cannot be said to be a regular market price for beryl in this country, and sales are probably a matter of bargaining. High freight rates have made it difficult to market South Dakota material in the East. The demand in the United States, however, is small—all less than carload lots—and much of the beryl market in the East has come from New York State.

Further details are given in Information Circular 6190, "Beryllium and Beryl," which may be obtained from the United States Bureau of Mines, Department of Commerce, Washington, D. C.

Symposium on Automotive Materials

The American Society for Testing Materials will hold a regional meeting in Detroit, March 19, with headquarters at the Book-Cadillac. The program includes:

"Present-Day Methods in Production and Utilization of Automotive Cast Iron," A. L. Bogehold, General Motors Co.

"Sheet Steel for Automobiles," W. H. Graves, Packard Motor Car Company.

"Corrosion-resisting and Heat-resisting Steels for Automobiles," C. M. Johnson, Crucible Steel Co.

"Advances in Die-cast Metals and Alloys for Automotive Use," C. Pack, Consulting Chemist.

"Developments in Light Metals and Alloys for Automotive Use," Z. Jeffries, Aluminum Co. of America.

"Automotive Bearing Metals," C. Upthegrove, University of Michigan.

"Recent Progress in Tests for Automotive Materials," H. F. Moore, University of Illinois.

Other papers will deal with motor fuels, lubricants, finishes, molded plastics and rubber.

Many Committee meetings will be held in the days preceding or following the regional meeting.

Translation

Negotiations are now under way which will assure the appearance of translations of articles appearing in foreign publications. Under this arrangement, the readers of METALS & ALLOYS *will be assured of receiving in English the best articles at almost the same time as they appear abroad instead of three months to one year later.*

The Origin of the Casting Structure

By G. Tammann, Göttingen, Germany

(*Translated by Special Arrangement from Zeitschrift für Metallkunde, September 1929, pages 277–282.*)

The solidification process in liquid metals cannot be observed directly because metals are opaque; an investigation of this process must, therefore, be carried out in transparent melts, especially of easily-melting materials.

The results of such investigations can be carried over to the solidification process in metallic melts as the structure of their solidification products corresponds to that of the solidification products of transparent melts.

There are two kinds of solidification on cooling melts: 1. The solidification of glass in which the melt becomes a homogeneous glass without separation into a solid and a liquid part; this solidification takes place in one temperature interval, no matter whether the melt consists of a single or several materials. In metallic melts, this type of solidification does not occur. 2. The solidification by crystallization; here, an accumulation of crystals originates from the melt, a conglomerate of crystallites. If the melt consists of a homogeneous material the composition of all grains is, of course, the same and crystallization takes place entirely at a definite temperature. The size of the grains, however, depends on the velocity of cooling; with slow cooling or slow carrying away of heat the grain of the casting is coarse; with quick carrying away of heat, fine. For very slow reduction of heat the size of grain may grow to that of a single crystal. The whole melt is transformed into a single crystal of the shape of the container in which the crystallization of the melt took place.

Melting Point and Solidification Temperature

If a melt is cooled below the melting point of the crystals from which it originated the crystallization in it does not necessarily start at once, the melts can be more or less under-cooled. The longer they are kept at a certain under-cooling the more probable is the occurrence of crystallization. An under-cooled melt is unstable, and the more so the lower it is under-cooled.

The melting point is the equilibrium temperature between the crystals and their melt during which they exist side by side for any length of time if no heat is added to nor taken away from the mixture of melt and crystals. If heat is added the number of crystals decreases, if heat is taken away the amount of melt decreases whereby the temperature is not changed, since with a decrease of the number of crystals their heat of fusion is bound, and with decrease of the amount of melt its crystallization heat is developed.

If a little crystal of an easily melting material is heated in a test tube the occurrence of liquid can be recognized at a certain temperature because crystals can, in general, not be overheated. At higher temperatures, though, the observation of the beginning of melting must be abandoned and an indirect method must be used, namely, by taking heating and cooling curves. The temperature of the cooling melt is observed in equal time intervals with a suitable thermometer put into the melt and the observed temperatures are plotted as a function of time. Fig. 1 represents the heating and cooling curves of the same material. At the temperature at which the crystals melt the heat of fusion is absorbed by them and the temperature, therefore, does not change at this point for a certain length of time. If everything has melted the temperature increases rapidly. When cooling, crystallization heat is liberated and, therefore, the cooling at the melting point is delayed so much that again the temperature is for a time unchanged. If the amounts of the material taken are not too small, critical points of the cooling and heating curves coincide, otherwise the critical point of the heating curve is somewhat higher than that of the cooling curve.

If a melt can be under-cooled a sudden increase of temperature takes place on the cooling curve at "a," Fig. 2. At the temperature "a" the first crystallization centers have formed from which crystals are shooting into the cooling melt whereby the temperature quickly rises to that of the melting point.

On the cooling curves of many metals no appreciable under-cooling occurs, then the true under-cooling is less than 1°; on others, as in liquid gold, antimony and bismuth, noticeable under-cooling of from 3–10° occurs quite regularly, and in nickel-iron the under-cooling can be as high as 100°.

Number of Crystallization Centers—Their Relation to the Under-Cooling

If a little glass tube with very thin walls with an easily melting material is dipped into a bath of a temperature above that of the melting point and if the tube with the melt is brought into a bath of a temperature below the melting point it can be observed that, starting from one or more points in the melt, needles are shot into the under-cooled liquid. With increasing under-cooling the number of these points increases noticeably and the time, until the first needles are seen, decreases. If the velocity with which the needles shoot into the melt is not too great, the points from which crystallization sets in can even be counted. At low crystallization velocities formations often occur which are called spherolites, their surface is sphere-like; from a point in their center, needles radiate between which other needles crowd, increasing with the distance from the center. Fig. 3 shows the structure of such a spherolite. The crystallization center is situated in the middle from which the little needles are growing in all directions.

In materials which can be converted into the glass-state, the number of these spherolites has a maximum value at a definite under-cooling, at still further under-cooling their number becomes exceedingly small. This case does not occur in metals. In a metallic melt, the number of the centers increases with under-cooling. Even if metals are precipitated from their solutions at temperatures far below their melting point, they always precipitate as small crystals, for instance, dissolved gold is precipitated from hot glass as ultra-microscopic crystals, and in the electrolysis

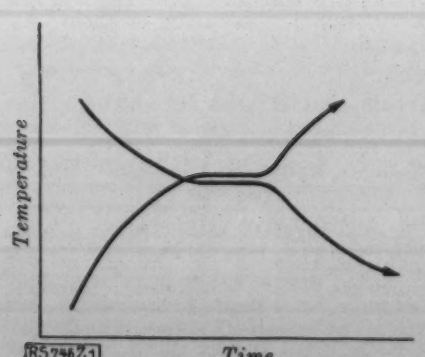


Fig. 1.—Cooling and Heating Curves

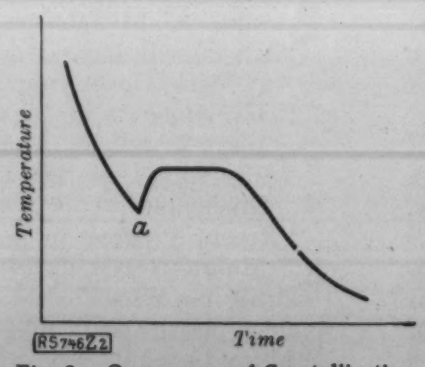


Fig. 2.—Occurrence of Crystallization After Under-Cooling

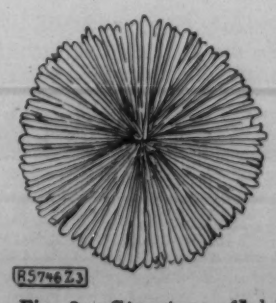


Fig. 3.—Structure of a Spherolite

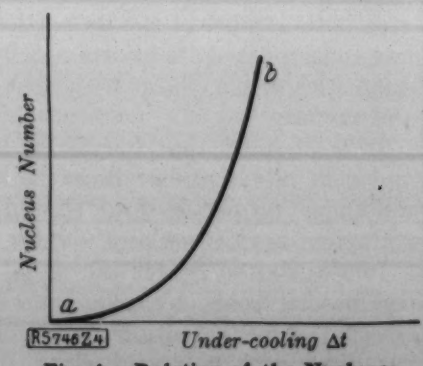


Fig. 4.—Relation of the Nucleus Number to Under-Cooling

of solutions at 20° metallic crystalline precipitations are always formed.

A crystallization center may be imagined to be an elementary crystal, for instance, a little cube with atoms on its eight corners. With its formation in an under-cooled liquid its temperature must not rise by the liberation of the crystallization heat above that of the melting point. For that reason, its formation can occur only in those atomic zones in which eight atoms have transitorily unusually low energies. Since with slight under-cooling the energy of a zone with eight atoms in which a crystallization center can be formed must be very small, such zones are rare in the melt and consequently only very few crystallization centers will originate with slight under-cooling. The greater the under-cooling of the melt, the smaller is the energy difference of the zones capable of crystallization in comparison with their average energy, the more frequent become these zones and the larger also becomes the number of crystallization centers in the same volume and in the same time.

The curve "a b" in Fig. 4 shows the relation of the number of centers in one minute in 0.1 cm.^{3} for under-cooling. A few degrees below the melting point it is very low, practically zero, then increases with the under-cooling slowly at first and then rapidly.

The Linear Crystallization Velocity

The linear crystallization velocity can easily be determined in transparent melts as dependent upon under-cooling. If the melt of a material which can be deeply under-cooled is placed in a U-tube and inoculated at a certain under-cooling with a small crystal of the same material, crystal threads are formed in the melt, the ends of which grow into the melt and the movement of this in mm./min. can easily be read on a scale. In the tube benzophenone is placed, melting point 49°, undercooled to 20°. If the meniscus is touched with a glass thread which first had touched a crystal of benzophenone the crystallization starts beginning from the point of inoculation.

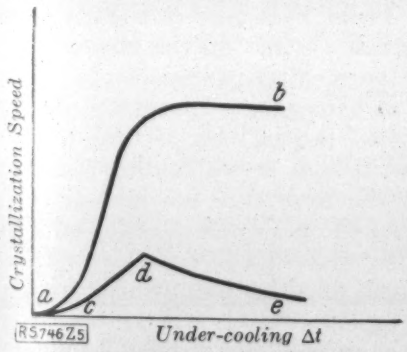


Fig. 5.—Relation of Crystallization Speed to Under-Cooling

With increasing under-cooling the crystallization velocity increases, Fig. 5, curve "a b," and reaches a maximum value which is characteristic of the respective crystal. If this value is smaller than 4 mm./min. the crystallization velocity does not become independent of the under-cooling but a maximum is formed, curve "c d e." For larger under-cooling the crystallization velocity like all conversion velocities, decreases with decreasing temperature.

The linear crystallization velocity is influenced in the range of under-cooling in which it increases with under-cooling. i. e. with falling temperature, only by the flowing away of heat. It is increased if a good heat conductor, a copper rod, is introduced into the melt.

But not only the displacement velocity of the ends of the crystal threads is determined by the heat flow at their boundaries with the melt but also the number of crystals increase with increasing heat flow, i. e. with increasing under-cooling.

The crystallization heat "r" can, if the specific heat of the crystal threads is "c," raise the temperature of the under-cooled melt by Δt if it is liberated instantaneously whereby the whole mass crystallizes. $\Delta t = \frac{r}{c}$

For under-cooling which is smaller than Δt, part of the melt remains liquid and with decreasing under-cooling the number of crystal threads decreases.

The liberated crystallization heat delays the linear crystallization velocity, and that the more so the smaller the under-cooling is. At the ends of the crystal threads shooting into the melt the temperature of melting exists. The amount of heat flow is determined by the temperature gradient in the melt at the ends of the crystal threads which are surrounded by a warmer layer of thickness δ. If the temperature of the under-cooled melt is "t" the temperature gradient is $\frac{t_s - t}{\delta}$ and this is proportional to the amount of heat flowing away, which, in its turn, is proportional to the displacement of the ends of the crystal threads. With decreasing under-cooling $t_s - t$ the crystallization velocity must, therefore, decrease. Since δ also changes and increases with decreasing under-cooling the crystallization velocity does not increase exactly in proportion to the under-cooling but faster, especially with smaller under-cooling.

The formation of directed crystal threads is known to the foundryman as radial crystallization. The reason for the formation of crystal threads is as follows: equivalent crystallographic planes are displaced in the melt with equal velocities, different ones with different velocities, this difference increases with under-cooling.

The formation of crystal threads is due to the different velocity of growing of different crystal planes, the plane of greatest crystallization velocity is displaced in relation to the heat flow whereby liquid layers having the temperature of the melting point are penetrated, slide along the long sides of the threads and impede the thickening of the threads due to their higher temperature.

The Formation of the Grain Structure in a Casting

When a melt is cooled, crystallization centers are formed in it from which either well-formed crystals or crystals with rounded-off edges and corners, or tree-like formations, dendrites or spherolites grow into the melt. The shape of these formations is rather immaterial, it is essential that they meet when growing. The areas in which this takes place are then the border faces of the grains of polyhedric shape. Fig. 6, a section through the crystallizing melt, will represent the formation of the grain. Around the crystallization centers cubes may grow in irregular orientation. The sectional plane will then intersect with most of the crystals in triangles. The thin lines are the cutting lines of the cutting planes with the planes of the cubes which float in the melt orientated irregularly. The sections through the faces in which the planes of the growing cubes meet are the thick lines, that is, sections through the border faces of the polyhedric bodies. These faces are diverted irregularly against the crystallization axes of the grains which, for this reason, are not called crystals but crystallites.

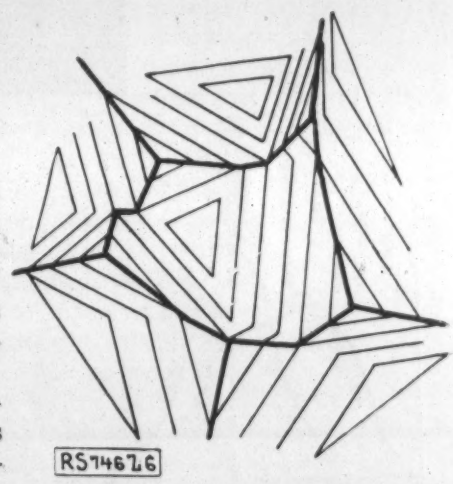


Fig. 6.—Grain Formation

The origin of this structure in transparent melts can also be observed directly. Between 2 glass plates a layer of methol just melted is placed, melting point 43°; with sufficient under-cooling the crystallization centers are formed from which the crystallization expands until the borders of the individual crystallites meet in lines forming a polygonal net.

Perfectly built crystals do not always grow in the melt but from one nucleus a needle shoots into the melt from which cross-needles grow making definite angles and from these again cross-needles. A tree-like structure is formed, a dendrite. These needles seek the coldest spots of the melt, they surround themselves with layers heated to the temperature of the melting point and emit sprouts there where these layers are removed by currents. Later the needles grow thicker and by further sprouts grow together into a mass, a grain which is a real crystal in its inner structure because the formation of new branches and their displacements take place in crystallographically prescribed manner.

In each crystallite exists, at the described dendritic crystallization, a dendrite, in different grains the dendrites are orientated differently in reference to one another. In a chemically homogeneous metal the dendrites in the grains cannot be made visible by etching but as they frequently occur on the free surfaces of castings it can well be assumed that they originate much more frequently than is generally assumed. In the castings of binary solid solutions the dendrites can be made visible by etching the ground surface because they are as first formed precipitations richer in that metal by the addition of which the melting point is increased.

Such a net is also visible on the ground plane of a casting; to each mesh of the net belongs a crystallization center which, naturally, only seldom lies in the ground plane.

An idea of the shape of the growing crystals can be formed from the shape of the border lines. Almost straight and smooth border lines point to the growth of crystals limited by planes or curved surfaces, Fig. 7,[1] while sharply indented lines point to the growth of dendrites, Fig. 8.[1] The number of crystallites depends: (1) on the number of crystallization centers which grows with under-cooling and time, and (2) on the linear crystallization velocity which likewise increases with under-cooling. The under-cooling influencing both factors increases in its turn with time, heat conductivity of the melt and of the mold.

If the number of crystallization centers is large and the crystallization velocity small the grain becomes small, in the reverse case large.

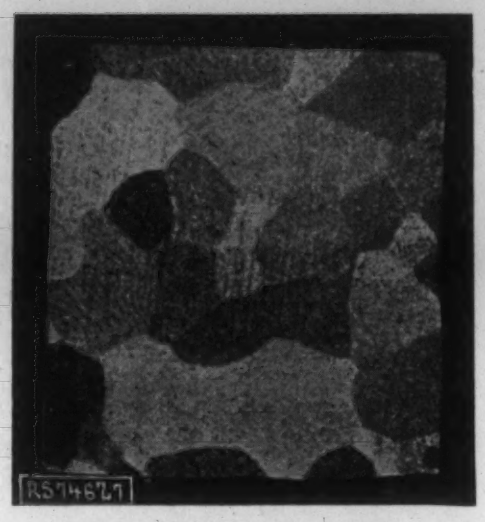


Fig. 7.—Cast Structure of Tin

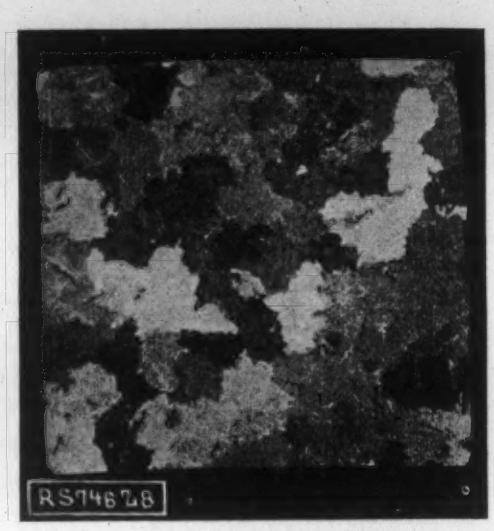


Fig. 8.—Cast Structure of Aluminum

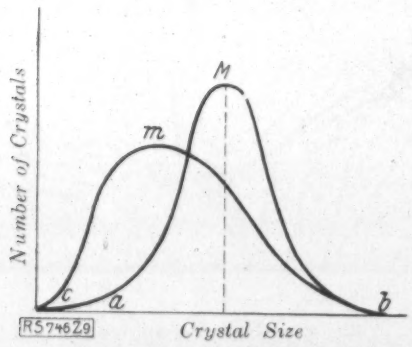


Fig. 9.—Variation in Crystal Size

It is important to know the number of grains for different conditions. This can be determined by counting.

Variations of Grain-Size in a Casting

If it were possible to separate the grains of a casting from one another they could be arranged in groups according to their size and represent the number of crystallites in each group as a function of the average size of each group. Such a curve would have the shape of the curve "a M b" of Fig. 9.

From the shape of the curve it can be judged if the crystallization centers of the grains of a zone of the same under-cooling originated at one and the same time, or if their origination extended over a longer time. If the crystallization centers of a zone originate at the same time and spherical surfaces which toward the end of the crystallization touch one another move from them with equal velocity into the melt, the frequency of the radii of these spheres must be determined by the curve "a M b" as a function of their length as the crystallization centers are irregularly distributed in the melt. For the frequency of the size of the spheres or that of the crystallites as a function of their size curve "a M b" must also be valid. This curve, the Gauss-distribution, is distinguished from other distribution curves by its symmetry. A definite size occurs most frequently, larger or smaller are less frequent. The frequency of each smaller grain-size corresponds to a larger grain-size of equal frequency which are different by equal amount from the most frequent.

If the Gauss-distribution of grain-size is found it can be concluded that the formation of the crystallization centers has lasted only a very short time. If it had lasted a longer time the number of smaller grains in the casting should be the larger, the longer the formation of crystallization centers has lasted. The distribution curve would then have to have the shape of curve "c m b." The reason, that the Gauss-distribution is actually found, lies in the simultaneous origination of the crystallization centers in a zone of the same under-cooling. This is quite comprehensible, because, after formation of the centers and the beginning of the crystallization, the temperature of the melt is fast increased by liberation of the crystallization heat and comes near the melting point where the number of new crystallization centers is comparatively small.

The counting of grains of equal size can only be done on a suitable etched ground plane. The grains appear reduced on the ground plane except those which are cut in their largest circumference. For this reason, the counting of the grains in the section of the ground plane does not give the exact Gauss-distribution but a somewhat different one. The calculation of this curve of the distribution of grains in the section will not be further discussed here. But, since the latter was calculated under the assumption of Gauss-distribution for the grain-size and agrees with the one found by counting, it may be stated that, in general, the formation of crystallization centers in the zones of the same under-cooling lasts only a very short time.

The average grain-size decreases considerably with increasing cooling velocity but the variations of grain-size around their average value should be according to the Gauss-distribution independently of the cooling velocity.

For the frequency of the grain in relation to its size, the Gauss-distribution does not hold good in re-crystallized metal pieces; but another one, the Maxwell-distribution.

The Radial Crystallization

Very often castings contain 3 zones of different texture. (1) The outermost layer consists of regularly orientated grains; this is followed by (2) the radial-layer with long-stretched threads arranged parallel to one another, and (3) in the innermost part again irregularly arranged grain exists.

But it can also happen that the whole casting consists of radial crystals and the case also occurs that the radial-layer is entirely missing.

The explanation of these phenomena will be dealt with in the following.

The melt is hot and the mold is cold, heat must flow away from the melt so that crystallization can set in. In the layer of the melt contiguous to the wall of the mold the temperature drops fast, under-cooling takes place and irregularly orientated nuclei originate which grow into grains. During this occurrence the crystal planes of those grains with high crystallization velocity begin to push themselves into the melt. If the heat flow is large at good heat conductivity of the mold this pushing will go fast, otherwise more slowly.

Let us assume a cylindrical form filled instantaneously with a chemically pure melt, then the radial crystals will grow to the center because as the layers of the melt at the ends of the stems have the temperature of the melting point the melt cannot under-cool and, therefore, no nucleus-formation can take place in the zones near the center. The different heat conductivity of the molds can, in this case, lead only to faster or slower lengthening of the radial crystals.

Matters are different if impurities are present in the metal; these will accumulate in the layer of melt at the ends of the radial-crystals, this will cause the temperature here to fall below the temperature at which the inner melt is in equilibrium with the crystals and under-cooling of the inner layers becomes possible. If it has become sufficient, nuclei originate in a zone at the ends of the stems, then in the following, and so on these nuclei grow into grains which finishes the solidification. At the border between the ends of the radial crystals and the grainy inner mass the under-cooling has become so great (with different metals 0.1–5°) that formation of nuclei can start.

The faster the heat is taken from the melt the faster radial-crystallization goes on and the shorter time is available for the drop in temperature of the inner melt to nucleus-formation, and therefore the radial-layer becomes thicker with increasing heat flow and can proceed, even if impurities are present in the melt, to the middle of the casting. The heat flow is made slower by reduction of the heat conductivity of the mold, in the sand mold the radial-layer is thinner than in the metal mold, and may even disappear, further by pre-heating the mold and by over-heating the melt because this pre-heats the mold and the heat flow is smaller during the radial-crystallization than if the melt was not overheated. With good heat-conductivity the heat flow during crystallization increases with the mass of the mold, the radial-layer, therefore, is thickened.

These relations of the radial-layer to the heat-flow from

[1] From J. Czochralski, *Moderne Metallkunde*, Julius Springer, 1924.

the melt are normal. They can, however, be changed quite considerably if the number of nuclei depends not only on the under-cooling but also on the over-heating of the melt, in such manner that with increasing over-heating the number of nuclei is reduced for the same under-cooling. This changes the structure of the casting so that with increasing over-heating of the melt the thickness of the radial-layer increases while normally it decreases. A reduction in size of the little graphite flakes with increasing over-heating of cast-iron has been observed by Piwowarski[2] and Hanemann,[3] a reduction of nucleus-formation with increasing overheating in aluminum by Scheil[4] and in copper by Seibe.[5] The explanation of these observations is still uncertain.

If a material is melted carefully, not overheated, all nuclei in it disappear because a very small crystal has a somewhat lower melting point than a large one. In the smallest crystals (nuclei) the melting point may lie about 2° below that of the larger. And yet the nucleus-number at the same under-cooling may be smaller after stronger over-heating than after lesser over-heating. The reason for this must be looked for in the fact that not all molecules go over during melting immediately into the isotropic state, a small part remains anisotropic with lower energy contents and is, therefore, more capable of forming nuclei than those having become isotropic. The higher and the longer over-heating goes on the smaller the number of these molecules becomes and with their number also the number of nuclei decreases.[6]

The nucleus-number is very sensitive with regard to impurities; very small quantities of impurities can increase the number of nuclei considerably, but also diminish greatly. During overheating of a melt appreciable quantities of the material of the crucible may be dissolved and hereby the nucleus-number can be reduced.

It should be determined by systematic experiments which impurities increase the nucleus-number, and which reduce it. The additions which increase the number of nuclei would be of practical importance.

At the crystallization of eutectic melts the formation of the radial-layer cannot be expected because here the different kinds of crystals can obtain a noticeable size only with abnormally long cooling, but remain small at normal cooling velocities.[7]

Hollow Capillaries in Castings

Usually a reduction in volume occurs on crystallization which makes itself especially felt by the formation of pipes. This is not the place to discuss the problem of the foundryman to prevent the formation of pipes by proper construction of the gates. It is of utmost importance to direct the flow in such manner that it remains impossible for the liquid metal to flow into the central, last liquid parts of the melt, and that no frozen bridges are formed preventing the flow.

But even though the casting has been successful without visible formation of pipes, microscopic hollow channels still exist in it especially at the lines where 3 crystallite faces meet because here the last remainders of the melt crystallize with a reduction of volume and the melt cannot enter these capillaries because they are either closed or filled with gases from the melt.

That at the very end of the crystallization a system of channels exists in the almost solidified mass can be observed in a melt which crystallizes with increase of volume. After the outer volume of the casting (bismuth) is defined by solidification of at least 90% of the mass a little drop of bismuth emanates from the center of the surface under warping of the latter at the border of three crystallites; this drop comes from a widely spread capillary net in the interior as its volume is 40% of the increase of volume of the entire mass of bismuth.

The existence of such systems of channels in castings which crystallize under reduction of volume can be proved by impregnating the casting with an eosin-solution (eosinic acid of potassium 20%) at from 50 to 100 atmospheres pressure.[8] Under the high pressure the eosin solution penetrates into the capillaries opening on the surface and dissolves the gas contained in them which after the lowering of the pressure does not develop further; the deeply colored penetrated solution remains in the casting. If the piece is then rasped and the filings are treated with water the contents of eosin can be determined colorimetrically and from this the volume of the hollow channels opening into the surface can be calculated. The volume of these channels amounts, for zinc-sheet to about 2% of the total volume, for copper-sheet to 0.5% and drops for bismuth castings below the amount of 0.05% determinable with certainty.

In base metals, the penetration of water into these channels can lead to deep-seated corrosion.

The Intermediate Substance between the Crystallites

Every metal, even the so-called "purissimum" still contains impurities. According to Mylius[9], the contents of foreign additions can only very seldom be brought down to 1×10^{-9}. Since there are 6×10^{23} atoms of a metal in a gm.-mol. the number of foreign atoms in the gm.-mol. in about 10 cm.^{3} is still something like 6×10^{17}. One part of these foreign atoms is distributed during the crystallization in the crystallites, these are particularly the metallic impurities. Another part: silicates, oxides, carbides, phosphides and sulphides dissolve in the crystallites much less than in the melt and accumulate, therefore, in the melt in the border layers with the crystallites. During the crystallization these layers are pushed by the growing crystallites before them and finally crystallize at the grain boundaries.

If a thin, small metallic plate (0.1 to 0.3 mm.), sawed off a casting, is dissolved without development of gas a delicate film remains having a honey-comb structure. In each honey-comb there was before solution, a crystallite. The remaining cell-walls of the film correspond, therefore, to the layers of the intermediary substance between the crystallites. When observing the solution under the microscope the solution of the grains and the remains of their envelopes can be clearly recognized.

The film of a casting or of a soft-iron sheet re-crystallized near the melting point has the honey-comb structure of Fig. 10, the film of a hard sheet-iron the tissue structure of Fig. 11.

Fig. 10.—Honey-Comb Structure of the Intermediate Material

Fig 11.—Fluid Structure of the Intermediate Material

Cadmium dissolves quickly without development of gas in a 40% ammonium-nitrate solution. The purest cadmium (Kahlbaum) leaves a network which can be dissolved to the greatest extent in hydrochloric acid (oxides) the remainder can only be dissolved in hydrofluoric acid (silicates). After a sublimation in vacuo the remaining film has become still more delicate, after a second sublimation it is no longer coherent but disintegrates into several pieces which float in the solution.[10] The amount and composition of these films of the intermediary substance will change with the kind of solvent.

The intermediary substance is of importance for the working and the heat treatment, in the first place it determines the grain-size in the re-crystallization.

The question at which temperature the last remnants of a melt crystallize as a eutectic of many materials cannot be answered definitely. It may be at 100°, or even 200–300° below the melting point of the metal. In any case, the principal amount of this eutectic crystallizes at the grain-boundaries which is also proved by the experience that hot-fracture at a temperature above eutectic temperature passes through the partly liquified intermediary substance, that is, not through the grains proper, as it does at lower temperatures below the eutectic temperature.

I have attempted to describe roughly the origin of the casting structure. Many conditions which influence it could not be discussed at all, as for instance currents during the teeming into the mold, convection currents, currents caused by reduction of volume during crystallization. The importance of a structure suitable for the working of the castings has been recognized and appreciable contributions have been made in this direction.[11] But we have not yet arrived at the end of the development in the technological production of the most suitable casting structure.

[2] E. Piwowarski, *Report of the Committee on Materials of the Verein Deutscher Eisenhüttenleute*, June 17, 1925, No. 63.
[3] H. Hanemann, *Monatsblätter des Berliner Bezirksvereins deutscher Ingenieure*, April 1, 1926, No. 4.
[4] E. Scheil, *Zeitschrift für Metallkunde*, **21**, 122 (1929).
[5] E. Seibe & P. Katterbach, *Zeitschrift für Metallkunde*, **19**, 179 (1927).
[6] G. Tammann & Othmer, *Zeitschrift für angewandte Chemie*, **91**, 207 (1915).
[7] G. Tammann & Botschwar, *Zeitschrift für anorganische und allgemeine Chemie*, **178**, 325 (1929).
[8] G. Tammann & H. Bredemeyer, *Zeitschrift für anorganische und allgemeine Chemie*, **142**, 54 (1925).
[9] F. Mylius, *Zeitschrift für anorganische Chemie*, **74**, 407 (1912). Compare also *Zeitschrift für Metallkunde*, **14**, 271 (1922).
[10] G. Tammann, *Zeitschrift für anorganische und allgemeine Chemie*, **121**, 275 (1922).
[11] E. Seidl & Schliebold, *Zeitschrift für Metallkunde*, **17**, 225, 283 and 320 (1925).

Book Reviews

Sparking of Steel. By E. Pitois. Translated by John D. Gat. Chemical Publishing Co., Easton, Pa., 1929. 89 pages, 32 plates. Price, $2.00.

The first book to be published on this subject, "Sparking of Steel," by Pitois-Gat, will be of value to those interested in this branch of testing. Spark testing is the classification of steel according to its chemical composition by visual examination of its grinding sparks. It offers a fast, cheap and reliable method for sorting steels of mixed analysis within certain limits.

Pitois has introduced his subject with an excellent summary of the purpose and limitations of the spark test. Detailed descriptions with photographs are given for carbon steels of increasing carbon content. Certain of the alloy steels are treated in a like manner. The descriptive phase is at times so exact as to appear misleading, but it must be remembered that this means is taken to call the student's attention to characteristics which, once seen and learned, can be relegated to their proper importance or lack of same.

The apparatus used for studying sparks is described, as is the photographic technique. An interesting side light is the use of this apparatus for testing of valve steels for internal combustion engines.

The chapter by Mr. John A. Houtz is a valuable addition to the book, rounding out the subject with many pertinent details of plant technique and equipment. He also augments Pitois' notes on spark characteristics of certain alloys.

The average trained spark tester is apt to lose his sense of proportion and eventually to commit himself to certain limits which are very close to those usually allowed for chemical error. Pitois has admirably avoided such statements, keeping his claims for the practice well within the range of practical application.

The photographs may appear disappointing to some, but those acquainted with the difficulties attendant to this phase will congratulate the author upon his success. The use of carbon content in the titles of these photographs, instead of classification by comparative hardness, would have been of assistance. The chapter on "Incrustations" seems rather pointless. It is agreed that this phase of the subject has possibilities, but it would have been better to have delayed publication until more conclusive data were available.

Mr. Gat has done well to bring this book before American chemists and metallurgists with their sorting problems incidental to tonnage production of alloy steels. The book is recommended both to experienced spark testers and to those who wish to gain some knowledge of the subject.—C. H. McCollam.

Die metallurgischen und metallographischen Grundlagen des Gusseisens. By K. von Kerpely. Wilhelm Knapp, Halle (Saale), Germany, 1928. $9^3/_4 \times 6^1/_2$ inches, 116 pages, 135 figs., 34 tables. Price, paper 7.50 R. M.; cloth 8.90 R. M.

This valuable contribution to the literature of cast iron is Part 7 of a series of books on iron, steel and non-ferrous foundry practice, edited by Hubert Hermanns. It was written taking into account recent metallographic and metallurgical investigations. Much of the material is based on tests and microscopic examinations of defective castings. Particular attention is paid to the effect of superheating, especially in electric furnaces. Reference is made to many theories advanced to account for facts, which have not been definitely accounted for by tests or experience.

The author discusses the grain of cast iron and the origin of each variety. He treats of the influences of each of the 4 usual elements (Si, Mn, P and S), singly and in combination; of the influence of graphite on the grain; takes up especially the influence of silicon on graphite, and also shows the influence of aluminum, titanium, nickel and chromium on the carbon content and character of the grain. The relation of the mechanical properties of cast iron to the grain and treatment are also very clearly and exhaustively considered.

The book is a trifle too technical to be used as a text or reference book for the average foundryman, even if it were not written in a foreign language.—Richard Rimbach.

Steel Treating Practice. By Ralph H. Sherry. McGraw-Hill Book Co., 1929. Cloth, 6 × 9 inches, 399 pages, 174 figs. Price, $4.00.

This book is said to have "been written, not for the technician, but rather for those who desire a general view of the field covered in steel treating practice." It avoids theory as much as possible, and would hardly be suitable as the sole text book in a college course. It does not go into enough detail to be of very much value to the practical heat-treater. Yet, it will be of use both to the student and the practical man in giving a bird's eye view of the subject.

It is very much condensed, giving a few sentences of correct statements on many subjects ranging from basic principles and the equilibrium diagram to furnace design, pyrometry, building design and distribution of overhead costs. The nitriding process, for example, is dismissed in part of a page. While it whets the reader's interest, it does not indicate where he may find further information. Outside of charts from the S. A. E. handbook, there is only one reference to other literature, that being in acknowledgment of a table copied from a paper published in 1914. No one would know from this book that any other author had ever dealt with steel treating.

The book covers much more briefly, and on the whole somewhat less satisfactorily, about the same fields as are covered in the Bureau of Standards' "Outline of the Principles of Heat Treatment and Bullen's Heat Treatment of Steel," together.

Nearly every metallurgist has beginners in his organization who would profit by getting such a picture of steel treating practise as this book will give. It will not add much to the knowledge of the experienced metallurgist.—H. W. Gillett.

Die Organisation der Wärmeüberwachung in technischen Betrieben. By Hans Balcke. R. Oldenbourg, München, 1929. Cloth, $5^3/_4 \times 8^3/_4$ inches, 312 pages, 213 figs. Price, 17.50 R. M.

The author has made a very commendable effort to produce a complete treatise on the present status of the industrial measuring science in Germany. The book is, therefore, more suitable for production executives and operating engineers than it is for use as a text-book. The material is largely devoted to measurements in boiler plants, other heating processes being given but little attention.

The book is divided into 3 parts: Part I deals with instruments and methods and considers the measurement of liquids, gases and vapors; pressure and draft; temperature, humidity, analysis of the products of combustion, distance transmitting of indications and records. Part II deals with the subject of heat efficiency in small and large boiler plants, furnace and gas producer operation, describing installations in boiler plants and in a steel plant as examples. Part III is devoted to automatic boiler regulation. In this part control of boiler operation is considered in some detail and the devices of "Askania" and "Arca" are described.

The reviewer can appreciate the partiality shown for German instruments as the book will probably have a limited circulation outside that country, but he cannot understand the very conspicuous omission of the instruments and apparatus of Siemens & Halske. This is especially evident in the author's consideration of thermoelectric and radiation pyrometers, CO_2 and $CO + H_2$ meters, psychometers and combustion controls, as competitive equipment is considered in detail in each case.—Richard Rimbach.

Physical Chemistry. By J. B. Firth. University Tutorial Press, London, 1929. 292 pages. Price, 5 s. 6 d.

In the early chapters are covered the general laws, atomic theory, Van der Waal's equation and the properties of gases and liquids. The phase rule, thermochemistry, catalysis, electrochemistry, the colloidal state and radio-activity are then discussed. This book is intended to meet the needs of students.—M. Berg Rimbach.

Select Methods of Metallurgical Analysis. By W. A. NAISH and J. E. CLENNELL. Chapman & Hall, Ltd., London, 1929. 6 × 9½ in., 495 pages, 32 figs. Price, 30 s.

This book is essentially a reference book of methods for general qualitative and quantitative chemical analysis. "The methods chosen have been selected on account of their accuracy and their general suitability for the purpose in view. Most of them have been actually tried by the authors."

Part I treats of methods of sampling, preparation of sample for analysis and general notes on volumetric analysis.

Part II includes the selected methods for the analysis of the elements arranged in alphabetical order, with particular attention being paid to the rarer elements.

Part III gives the methods of analysis of commercial metals, ferrous and non-ferrous alloys.

Part IV contains the complete analysis of ores, slags and metallurgical by-products as skimmings, dusts, mattes, scrap, etc.

Part V treats of the analysis of refractories and coal, while Part VI contains notes on electrometric titrations, analysis of minerals and spectrographic analysis.

Of the various parts, Part II is particularly noteworthy in its treatment of the rare metals schematically arranged for qualitative and quantitative analysis.

The bibliographies on each metal while sometimes slightly antiquated are, nevertheless, quite comprehensive. The parts dealing with commercial metals and metallurgical by-products are also very complete. But the sections on volumetric analysis, coal, electrometric titrations and the analysis of minerals leave much unsaid. Chemical microscopy, hydrogen ion concentration and photo micrography and X-ray analysis, which are now playing so important a part in metallurgical analysis, are hardly mentioned. The Section on spectrographic analysis reads almost like a reprint of some of the publications of Adam Hilger, Ltd.

It is unfortunate that the book in parts, is not more complete, but those parts which are thoroughly covered, give data not compiled elsewhere. This, along with the extensive bibliographies make it a handy reference work for the chemist and metallurgist called upon for rare analyses.—ARTHUR SCHRODER.

Analyse dilatometrique des materiaux. PIERRE CHEVENARD. With a preface by Ch. Ed. Guillaume, Director, International Bureau of Weights and Measures. Dunod, Paris, 1929. 80 pages, 34 figs., 6 plates. 8¼ × 11 inches. Price, paper 25.50 Fr., cloth 38.30 Fr.

Many interesting sets of relations existing between transformations taking place in solid substances and the changes of their dimensions on heating gradually bring into prominence the methods in which the history of transformations is followed by the record of the dimensional changes of the specimens. Dilatometric methods give more valuable data about a metal than any other procedure singly employed, not only recording the ultimate results but furnishing data leading to the explanation of the phases by which the final state was reached. The simplicity of the apparatus and of the operating procedure further adds to its value.

The name of Prof. Chevenard does not need an introduction to any one even remotely interested in dilatometric analysis. In the present booklet he expressed his views on the theory of dilatometric methods and described the gradual development of dilatometers bearing his name.

After reading the booklet one feels well acquainted with the basic principles of the method, the functioning of the apparatus and its construction. The presentation is clear and concise. The author's ideas regarding the salient points to be observed in the manipulation, the selection of proper objects for investigation and the extension of the usefulness of the method into new broad fields are worthy of the most thorough study.—JOHN D. GAT.

Index to A. S. T. M. Standards and Tentative Standards (as of September 3, 1929). American Society for Testing Materials, Philadelphia. 109 pages.

This indexes the 390 standards and 173 tentative standards of the A. S. T. M. The majority of these deal with metallic products and methods of tests relating to them. The index is to be an annual publication, and will facilitate the use of the specifications.—H. W. GILLETT.

The Practice of Spectrum Analysis with Hilger Instruments. Adam Hilger, Ltd., London, 1929. 4th Edition, 38 pages. 6 × 9¾ in. Price, 1 s. 6 d.

This concise treatise on the extensive but relatively little understood subject is too valuable not to be in the hands of everyone doing spectroscopic analysis, regardless of the make of the instrument employed. Compiled by F. Twyman, the designer of many Hilger Instruments, its value is greatly enhanced by contributions from E. N. Andrade and S. Barratt of University College, London; S. J. Lewis, D. M. Smith of the British Non-Ferrous Metals Research Association; A. A. Fitch of the Imperial College of Science, New Kensington, and J. W. Ryde of the General Electric Company's Research Laboratories at Wembley. The types of problems to which Spectroscopy is applicable, the apparatus to be used, the means of exciting emission spectra (flame, spark and exploded wire) directions for taking spectrograms, quantitative spectrum analysis and a discussion of the various types of spectrum, are all treated in sufficient detail to warrant the book serving as a guide in the solution of many mineralogical, metallurgical and chemical problems now beyond the scope of chemical analysis. While metals and metalloids are discussed at some length, the gases are not. It is hoped that future editions of the book will include this.—ARTHUR SCHRODER.

Oakland's 450 Ton Foundry in Operation

The achievement of Oakland Motors' expansion project with the completion of their new gray iron foundry of 250,000 sq. ft. floor area at a cost running into millions increases to 90% the number of Oakland-Pontiac made parts.

The new group of 7 conveyor connected buildings with service yard has a casting capacity of 450 tons daily, employs 1500 men mostly machine operators and is practically entirely automatic.

J. E. Linabury who has constructed foundries for other General Motors divisions, designed and superintended the construction of the plant. He also developed its equipment and facilities, which introduce many entirely new methods into foundry practice. They are designed to turn out castings as accurate in relation to foundry work as are the precision manufacturing operations in the Oakland-Pontiac engine building and assembly plants. In building the foundry, Mr. Linabury cooperated close with Gordon Lefebvre, Vice-president in charge of operations.

Equipment is almost entirely automatic. Miles of conveyors and overhead mono-rail trolleys simplify the movement of both raw and finished material.

Ten-ton magnets on a traveling crane with a span of 80 feet move pig iron and other raw materials from the storage yards to the cupola room. Automatic machinery measures and weighs the materials en route. Overhead cranes unload core sand from cars into 450-carload capacity bins and overhead trolleys later take it from storage and, after it is mixed, deliver it to the core makers. Automatic machinery mixes the sand, oil water and other materials that go into the cores. Conveyors take the core through the core ovens and cooling shafts into assembly rooms and past the ladles from which they are filled with molten metal brought to this point by mono-rail overhead cars. Special machinery even removes the forms and knocks away the waste sand and cores. Other conveyor systems take the castings to the cleaning, sand-blasting and grinding rooms and deliver them to the machine shops for finishing and assembling into Oakland and Pontiac automobiles.

The foundry's sixteen core ovens are said to be the first complete system of vertical ovens in the world. Cores ascend through them on an endless belt. Automatic heat control keeps each oven at a temperature of 450° F. After being baked the cores descend through a cooling chamber, reaching the floor ready for inspection and assembly. These ovens occupy but one-fourth the space required by the horizontal type, and the cores require much less handling than under previous methods.

The four cupolas, of the hot and cold blast types, are three stories tall and have an individual twenty-ton per hour melting capacity. Their melting heat is 2700° F. The almost automatic method of "charging" them requires only two men, a process formerly demanding many operators.

To achieve high quality in material and finished product, a corps of highly trained metallurgical engineers conduct laboratory tests close to the melting and casting room so that repeated checks of every process assure uniformity in the molten metal and in the resulting castings.

Patent Department

Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates a well-known Patent Information Service, we are able to publish every month a list of important patents in the metallurgical field from the United States, Canada and Europe. The following countries will be included in the European listing: England, Germany, France, Switzerland, Denmark, Norway, Sweden and Italy.

If our readers wish more information about any of the patents listed below they can get it by writing to our Patent Department, and mentioning the fact that they have seen the reference in METALS & ALLOYS. *We will be prepared to mail copies of United States Patents to clients within twenty-four hours of date of issue by special arrangement. Photostatic copies, translations of claims and of full text of foreign patents will be supplied if desired.*

This service is furnished under special arrangement with Mr. Corse's organization at most reasonable rates. Full information can be secured by writing to Patent Department, METALS & ALLOYS, *419 Fourth Avenue, New York.*

United States Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Conveyor for high-temperature furnaces. G. F. Beach, Philadelphia, Pa., assignor to F. J. Ryan and Co., Philadelphia, Pa. No. 1,739,497. Mar. 12, 1926.

Stamping process for making sheet-metal articles. P. Schwarz, Barmen, Germany. No. 1,739,524. Aug. 13, 1927.

Core for molds. G. Bühler, Vienna, Austria. No. 1,739,542. Oct. 29, 1928.

Tin-plate-cleaning machine. C. L. Inglefield, Bellevue and H. H. Giles, Monessen, Pa., assignors to American Sheet and Tin Plate Co., Pittsburgh, Pa. No. 1,739,593. Nov. 19, 1927.

Metal coiling apparatus. D. L. Summey, Waterbury, Conn. No. 1,739,620. May 24, 1928.

Electroplating device. R. B. Shemitz, New York, N. Y. No. 1,739,657. Jan. 16, 1928.

Core-making machines. R. S. Cicero, Waterbury, Conn. No. 1,739,663. May 17, 1928.

Welding apparatus. W. H. Pierson, Detroit, assignor to Briggs Manufacturing Co., Detroit, Mich. No. 1,739,691. Mar. 5, 1928.

Machine for the manufacture of nails from wire. J. Wikschtröm, Düsseldorf, Germany. No. 1,739,745. Aug. 27, 1927.

Magnetic material and appliance. G. W. Elmen, Leonia, N. J., assignor to Bell Telephone Laboratories, Inc., New York, N. Y. No. 1,739,752. Dec. 28, 1927.

Making welded spiral pipe. A. G. Hand, assignor to California Corrugated Culvert Co., both of Berkeley, Calif. No. 1,739,757. Apr. 3, 1928.

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Electrolytic precipitation of metals. U. C. Tainton, Kellogg, Ida. No. 1,739,772. Jan. 26, 1926.

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Blank-serving apparatus for rolling mills. E. A. Nelson, Abington, Pa., assignor to Budd Wheel Company, Philadelphia, Pa. No. 1,739,854. Apr. 9, 1925.

Mechanism for handling sand in foundries. E. S. Carman, East Cleveland, O., assignor to The Osborn Manufacturing Co., Cleveland, O. No. 1,739,887. Dec. 28, 1926.

Hollow roll. G. Baehr, McKeesport, Pa. No. 1,739,939. Dec. 14, 1926.

Electrical annealing. M. Farmer, Hartford, Conn. No. 1,739,958. Aug. 2, 1926.

Process of working up mixed shavings of white metal and red metal. A. Schwarz, Berlin-Weidmannslust, Germany. No. 1,739,992. June 10, 1927.

Manufacture of tools of tungsten. O. Diener, Breslau, Germany. No. 1,740,009. Mar. 20, 1928.

Hydraulic casting-washing apparatus. W. Watson, West Allis, Wis., assignor to Allis-Chalmers Manufacturing Co., Milwaukee, Wis. No. 1,740,052. Aug. 20, 1926.

Welded joint. W. G. Wehr, East Cleveland, O., assignor to The Cleveland Crane & Engineering Co., Wickliffe, O. No. 1,740,053. Mar. 10, 1927.

Galvanizing apparatus. B. P. Finkbone, assignor to The American Rolling Mill Co., both of Middletown, O. No. 1,740,081. Nov. 30, 1925.

Wiper for metal-coating machines. W. A. Painter, assignor to McCord Radiator & Mfg. Co., both of Detroit, Mich. No. 1,740, 114. Jan. 31, 1927.

Welding apparatus. C. C. Pinckney, Birmingham, Ala., assignor to Birmingham Tank Co. No. 1, 740, 117. Nov. 28, 1927.

Welding apparatus. J. C. White, assignor to J. M. Hutcheson, both of Eureka, Calif., of forty-nine one-hundredths. No. 1,740,133. May 23, 1924.

Method of removing chlorine ions from electrolytic solutions. V. Engelhardt, Berlin-Charlottenburg, Germany, assignor to Siemens & Halske Akt.-Ges., Siemensstadt, near Berlin, Germany. No. 1,740,165. Dec. 15, 1926.

Brick shapes for building blast-furnace linings and the like. J. C. Morehead, assignor, by mesne assignments to Inland-Stuart Linings, Inc., both of Pittsburgh, Pa. No. 1,740,258. July 12, 1928.

Coil holder. H. M. Naugle and A. J. Townsend, Canton, O., assignors, by mesne assignments, to the American Rolling Mill Co., Middletown, O. No. 1,740,260. June 25, 1927.

Furnace and method of operating the same. W. de Fries, Wilkinsburg, Pa. No. 1,740,288. Apr. 7, 1921.

Electrodes and process for making the same. C. G. Fink, Yonkers, and Russell E. Lowe, New York, N. Y., assignors to Bario Metal Corp., New York, N. Y. No. 1,740,291. Aug. 25, 1923.

Forge hammer. W. J. Hagman, Philadelphia, Pa. No. 1,740,341. Feb. 11, 1925.

Method of hardening articles. W. G. Hildorf, assignor to Reo Motor Car Co., both of Lansing, Mich. No. 1,740,347. Dec. 5, 1927.

Electric-arc welding. J. M. Weed, Scotia, N. Y., assignor to General Electric Company. No. 1,740,381. May 4. 1925.

Grapple for handling hot castings. I. L. Wessel, Muskegon, Mich., W. A. Wessel administrator of said I. L. Wessel, deceased. No. 1,740,383. June 13, 1928.

Method of treating shavings and scrap of light metal and alloys thereof. J. A. Gann, assignor to The Dow Chemical Company, both of Midland, Mich. No. 1,739,717. Nov. 8, 1926.

Coating and heat treating. A. O. Austin, near Barberton, Ohio, assignor, by mesne assignments, to the Ohio Brass Co., Mansfield, O. No. 1,740,639. May 25, 1925.

Alloy. W. Borchers, Aachen, Germany, and R. W. Stimson, New York, N. Y., said Borchers assignor to said Stimson. No. 1,740,678. Apr. 14, 1924.

Alloy. W. Borchers, Aachen, Germany, and R. W. Stimson, New York, N. Y., said Borchers assignor to said Stimson. No. 1,740,679. Apr. 14, 1924.

Forging machine. C. F. Osgood, Claremont, N. H., assignor to Sullivan Machinery Company. No. 1,740,708. June 6, 1928.

Method of preparing metal for painting. J. H. Gravell, Elkins Park, Pa, No. 1,740,731. Feb. 12, 1929.

Treating lead alloys. G. W. Thompson, Brooklyn, N. Y., assignor to National Lead Co., New York, N. Y. No. 1,740,752. Aug. 12, 1924.

Control for jarring molding machines. D. J. Campbell, Muskegon Heights Mich. No. 1,740,766. Dec. 10, 1924.

Molding machine. T. E. McFall, Sparta, assignor to Sparta Foundry Co., Sparta, Mich. No. 1,740,775. Apr. 23, 1928.

Side brass for rolling-mill housings. C. F. Peek, Chesterton, Ind. No 1,740,781. Aug. 15, 1927.

High-speed feed for sheet metal. R. W. Strout, assignor to E. W. Bliss Company, both of Brooklyn, N. Y. No. 1,740,844. May 19, 1928.

Process for the production of metallic beryllium. W. Kroll, Luxemburg, Luxemburg. No. 1,740,857. Sept. 26, 1927.

Magnetic alloy. W. S. Smith, Newton Poppleford, H. J. Garnett, Sevenoaks, and J. A. Holden, Gidea Park, England. No. 1,740,880. Nov. 2, 1927.

Hot-blast cupola. C. D. Barr and W. D. Moore, Birmingham, Ala., assignors to American Cast Iron Pipe Co., Birmingham, Ala. No. 1,740,886. Mar. 24, 1928.

Hot-blast cupola. W. D. Moore, assignor to American Cast Iron Pipe Co., both of Birmingham, Ala. No. 1,740,900. Nov. 15, 1927.

Arc-Welding system. C. J. Holslag, East Orange, N. J., assignor to Electric Arc Cutting and Welding Company, Newark, N. J. No. 1,740,983. Oct. 2, 1926.

Method of operating an open-hearth furnace. W. Trinks, Pittsburgh, Pa. No. 1,741,002. June 22, 1923.

Open-hearth-furnace structure and method of operation. R. B. Kernohan, J. S. Lochhead and W. Trinks, Pittsburgh, Pa. No. 1,741,025. Oct. 1,1921.

Flotation process. H. T. Koenig, O. A. Fischer, E. F. Hafey and A. B. Clampitt, Denver, Colo., assignors to R. H. Channing, Jr., agent, San Francisco, Calif. No. 1,741,028. Sept. 21, 1927.

Flotation process. S. P. Lowe and H. T. Koenig, Denver, Colo., assignors to R. H. Channing, Jr., agent, San Francisco, Calif. No. 1,741,030. Jan. 19, 1927.

Welding flux. W. B. Miller, Flushing, N. Y., assignor to Oxweld Acetylene Company. No. 1,741,031. Jan. 27, 1926.

Electric pipe-welding apparatus. W. E. Rupley, Los Angeles, Calif., assignor to Western Pipe and Steel Company of California. No. 1,741,076. Sept. 26, 1925.

Molding machine. J. T. Ramsden, assignor to The Taber Manufacturing Co., both of Philadelphia, Pa. No. 1,741,116. June 6, 1928.

Reactive packing for metallurgical refractories. C. S. Hollander, Philadelphia, and E. L. Helwig, Bristol, Pa. No. 1,741,128. Feb. 6, 1929.

Open-hearth furnace. R. B. Kernohan and J. S. Lochhead, Pittsburgh, Pa. No. 1,741,024. Oct. 29, 1920.

Safety guard for power presses. W. O. Will and E. Carlson, assignors to Stewart Manufacturing Corp., all of Chicago, Ill. No. 1,741,177. June 1, 1926.

Treatment of materials with binders in the briquetting of said materials. F. Lessing, London. No. 1,741,193. Oct. 6, 1927.

Method of tinning bearing shells and the like. V. Skillman, Highland Park. Mich., assignor to Bohn Aluminum & Brass Corp., Detroit, Mich, No. 1,741,204. Nov. 1, 1926.

Furnace and method of operating the same. E. H. Swindell and F. W. Brooke, assignors to William Swindell & Bros., Pittsburgh, Pa. No. 1,741,209. Jan. 29, 1923.

Straightening-die construction. L. Bortkewicz, Racoon Station, Pa. No. 1,741,278. July 25, 1927.

Ladle trolley. E. H. Kendall, assignor to The Alliance Machine Co., both of Alliance, O. No. 1,741,315. Mar. 9, 1928.

Carburizing material. G. W. Presser, assignor to E. F. Houghton and Co., both of Philadelphia, Pa. No. 1,741,336. July 14, 1928.

Metal-coating metal sheets. E. R. Wehr and C. C. Mahlie, assignors to The American Rolling Mill Co., all of Middletown, O. No. 1,741,388. Sept. 13, 1926.

Method and means for the alumino-thermic welding of rails and the like. E. F. Begtrup, Jersey City, N. J. No. 1,741,399. April 3, 1929.

Adjusting means for rolling-mill rolls. J. R. Coe, assignor to The American Brass Co., both of Waterbury, Conn. No. 1,741,405. Apr. 19,1928.

Electric furnace. J. R. Eves, assignor to Falls Electric Furnace Corp., both of Buffalo, N. Y. No. 1,741,411. Jan. 20, 1928

Method of welding rails. P. Rüggeberg, Berlin-Tempelhof, Germany. No. 1,741,437. Dec. 10, 1928.

Electric furnace. B. Long, Paris, France, assignor to Société' Anonyme des Manufactures des Glases & Produits Chimiques de St.-Gobain, Chauny & Cirey, Paris. No. 1,741,469. Aug. 9, 1928.

Method of metallizing the surfaces of insulating bands. E. Pfiffner, Fribourg, Switzerland, assignor by mesne assignments to Radio Patents Corp., New York, N. Y. No. 1,741,477. Mar. 25, 1926.

Polishing device for furnace conveyors. J. W. Banfield, Toronto, O., assignor to Follansbee Brothers Co., Pittsburgh, Pa. No. 1,741,494. Mar. 22, 1929.

Core-molding machine. V. H. Curren, Wilmington, Del. No. 1,741,503. June 28, 1928.

Vibrator for ore screens. A. L. La Mont, Fredericktown, Mo. No. 1,741,-528. Feb. 10, 1927.

Process for briquetting flue dust. E. A. Slagle, Trenton and B. M. O'Hara, Westfield, N. J., assignors to American Smelting and Refining Co., New York, N. Y. No. 1,741,544. Sept. 9, 1926.

Tube-mill shell liner. F. R. Barratt, Krugersdorp, Transvaal, South Africa. No. 1,741,604. Jan. 5, 1925.

Hot top for ingot molds. H. L. Coxey, Massillon, O. No. 1,741,615. June 25, 1927.

Open-hearth furnace. S. Treverton, Canton, O., assignor to Central Alloy Steel Corp., Massillon, O. No. 1,741,666. Sept. 8, 1927.

Soldering iron. D. A. Miller, Campbelltown, Pa. No. 1,471,707. Nov. 30, 1928.

Disk-rolling mill. J. W. Hughes, assignor to Budd Wheel Co., both of Philadelphia, Pa. No. 1,741,715. Nov. 3, 1926.

Alloy. J. V. O. Palm, Cleveland Heights, O., assignor to The Cleveland Graphite Bronze Co., Cleveland, O. No. 1,741,733. Sept. 30, 1926.

Metal-handling apparatus. G. A. La Rocque, Hartford, Conn. No. 1,741,-782. July 19, 1927.

Drop-forging hammer. H. Birmingham, Ashland, Mass., Wilfred J. Birmingham administrator of said H. Birmingham, deceased. No. 1,741,811. June 3, 1926.

Method of and means for working moldable matter. J. E. Boynton, Oak Park, Ill., assignor to Western Electric Co., New York, N. Y. No. 1,741,812. June 13, 1924.

Apparatus for producing composite articles. J. E. Boynton, Oak Park, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,741,813. Mar. 25, 1925.

Method of and apparatus for extruding matter. J. E. Boynton, Oak Park, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,741,814. Dec. 22, 1925.

Method of and apparatus for treating moving matter. J. E. Boynton, Oak Park, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,741,815. May 31, 1927.

Apparatus for pumping material. J. E. Boynton, Oak Park, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,741,816. June 9, 1928.

Sintering machine. J. R. Linney, Clinton County, N. Y. No. 1,741,943. Oct. 9, 1928.

Sintering machine. J. R. Linney, Clinton County, N. Y. No. 1,741,944. Oct. 9, 1928.

Tungsten-tantalum alloy. J. H. Ramage, Bloomfield, N. J., assignor to Westinghouse Lamp Co. No. 1,741,953. May 28, 1927.

Method of obtaining chromium. M. N. Rich, East Orange, N. J., assignor to Westinghouse Lamp Co. No. 1,741,955. Nov. 9, 1927.

Apparatus for cleaning castings. W. C. Speck, E. Barker, A. E. Whipple and A. H. Dierker, assignors to The Buckeye Steel Castings Co., all of Columbus, O. No. 1,741,959. May 9, 1927.

Apparatus for cleaning castings. W. C. Speck and E. Barker, assignors to The Buckeye Steel Castings Co., all of Columbus, O. No. 1,741,960. June 29, 1927.

Electric furnace. C. E. Cornelius, Stockholm, Sweden. No. 1,741,977. Nov. 10, 1928.

Method of brazing. F. P. Vincent, Elyria, O., assignor, by mesne assignments, to Steel and Tubes, Inc., Cleveland, O. No. 1,742,017. Oct. 4, 1926.

Ladle d scharger. G. H. J. Eises, Pittsburgh, Pa. No. 1,742,065. May 26, 1928.

Roll polisher. T. S. Groves, Leechburg, Pa. No. 1,742,070. June 6, 1928.

Process for the production of soft iron. B. Weishan, Sigmaringen, Germany. No. 1,742,111. Mar. 11, 1927.

Austrian Patents

Subject of Invention, Patentee and Patent No.

Patents whose term began July 15, 1929.

Process and apparatus for the electromagnetic preparation or enrichment of ores and other minerals. W. M. Mordey, Westminster, England. No. 115,858.

Apparatus for automatically winding up and unwinding spools of wire. A. Zopp, Mödling, Austria. No. 115,831.

Heating and annealing furnace. R. Schubert, Gerstl. (Post Böhlerwerke), N.Ö. and K. Pletsche, Bad Neuheim, Germany. No. 115,621.

Device for use in the operation of bright-annealing furnaces. Siemens-Schuckertwerke G.m.b.H., Berlin-Siemensstadt, Germany. No. 115,838.

Method of stripping metal cores from castings. S. Junghans, Villingen, Baden. Germany. No. 115,669.

Magnetic copper-iron-nickel alloy. W. S. Smith, Benchams and H. J. Garnett, Lymne, England. No. 115,614.

Lead alloy containing cadmium and heat treatment of the same. S. Beckinsale and H. Waterhouse, London, England. No. 115,617.

Process for preventing hot brittleness in alloys containing copper and tin. G. Arnstein, Vienna, Austria. No. 115,623.

Process for making anhydrous magnesium chloride for the production of magnesium by electrolysis. M. N. Lacelle, London, England. No. 115,616.

Electric resistance element for obtaining high temperatures. F. Neumann, Vienna, Austria. No. 115,624.

Apparatus for the continuous plating of sheets. F. Kirschner and J. Hess, Vienna, Austria. No. 115,881.

Process for the production of thin, superposed, easily separable layers of nickel and the like. E. Breuning and O. Schneider, Hagen, Westfalen, Germany. No. 115,618.

Process and machine for making lead-sheathed cables. Kabelfabrik Akt.-Ges., vormals O. Bondy, Pressburg, Czechoslovakia. No. 115,613.

British Patents

(Complete Specifications Accepted.)

Subject of Invention, Patentee, Patent No. and Filing Date.

Separation of dry materials. Birtley Iron Co., Ltd. and C. W. H. Holmes. No. 321,670. May 7, 1928.

Process and apparatus for washing materials, such as ores, coals and the like. L. Hoyois. No. 294,210. July 20, 1927.

Manufacture of tinned metal products. W. Hanby. No. 321,639. Aug. 3, 1928.

Recovery of copper and other metals from copper-bearing ores. F. L. Duffield. No. 321,685. Aug. 15, 1928.

Foundry-moulding machines. British Insulated Cables, Ltd. and T. W. Bullock. No. 321,777. Oct. 1, 1928.

Method and apparatus for cleaning blast-furnace gases or the like. H. A. Brassert & Co. No. 307,904. Mar. 17, 1928.

Nut-blank forging-machines. A. De. Fries. No. 321,834. Nov. 21, 1928.

Method and apparatus for annealing or coating metals. W. Hanby. No. 321,642. Aug. 3, 1928.

Manufacture of metal products covered with a coating of metal (e. g. zinc) or alloy W. Hanby. No. 321,643. Aug. 3, 1928.

Forging-machine. Ingersoll-Rand Co. No. 314,044. June 22, 1928.

Binder for foundry cores. A. Stahn. No. 303,858. Jan. 11, 1928.

Process for recovering sulphur and iron oxide from iron-containing sulphide ores or the like. H. D. Elkington (Comstock & Wescott, Inc.). No. 321,911. May 17, 1928.

Treating iron ores. Comstock & Wescott, Inc. No. 306,107. Feb. 16, 1928.

Coating metallic or non-metallic bodies with chromium. S. G. S. Dicker (Naamlooze Vennootschap Philips' Gloeilampenfabrieken). No. 321,-914. July 9, 1928.

Ferro-aluminium alloys. S. G. S. Dicker (Soc. Aubert et Duval Frères), No. 321, 936. Aug. 14, 1928.

Froth-flotation concentration of ores and the like. P. T. Williams and Minerals Separation, Ltd. No. 321,927. Aug. 18, 1928.

Baking a highly-refractory lining in metallurgical furnaces, especially induction furnaces, crucibles, and the like. S. Westberg. No. 310,458. Apr. 26, 1928.

Methods of producing magnetic materials. Standard Telephones & Cables, Ltd. (Western Electric Co., Inc.). No. 321,957. Aug. 22, 1928.

Welding-apparatus. D' A. M. Clark (Bendix Brake Co.). No. 321,975. Aug. 22, 1928.

Manufacture and production of finely-divided metal powders obtained from carbonyls. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 322,039. Sept. 28, 1928.

Hardening iron and steel articles by nitrogenization. P. F. M. Aubert, A. J. P. Duval and H. A. M. Duval (trading as Aubert et Duval Frères). No. 300,633. Nov. 17, 1927.

Obtaining smooth and dense electrolytic metallic deposits. Metallges. Akt.-Ges. No. 299,725. Oct. 27, 1927.

Removal from metal powders of the impurities which form volatile compounds with oxygen. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 322,082. Nov. 17, 1928.

Method of refining nickel copper matte. F. E. Lathe. No. 303,066. Dec. 27, 1927.

Production of anhydrous stannic chloride from metals containing tin. G. A. Favre. No. 304,282. Jan. 18, 1928.

Machines for making foundry cores. H. L. Demmler. No. 322,135. Feb. 14, 1929.

Roll-grinding machines. H. R. Williams. No. 322,142. Dec. 10, 1928.

Treatment of ores. S. G. S. Dicker (Bradley-Fitch Co.). No. 321,943. June 19, 1928.

Recovering sulphur from gaseous mixtures containing sulphur vapours. H. D. Elkington (Comstock & Westcott, Inc.). No. 321,919. May 17, 1928.

Recovering sulphur and iron oxide from iron-containing sulphide ores or the like H. D. Elkington (Comstock & Westcott, Inc.). No. 321,920. May 17, 1928.

Process and apparatus for the electrolytic removal of metal from metallic bodies. S. O. Cowper-Coles. No. 322,118. June 5, 1928.

Electric furnace. A. E. White (J. J. Naugle). No. 322,160. July 25, 1928.

Manufacture of iron chromium alloys. H. G. Flodin. No. 322,189. Aug. 28, 1928.

Method of and apparatus for pulverizing and treating materials. Erie City Iron Works. No. 313,582. June 16, 1928.

Apparatus for branning, dusting and polishing tin plates. S. Davies. No. 322,243. Sept. 6, 1928.

Electrolytic production of protective coatings of peroxide of lead on electrical conductors. Siemens & Halske Akt.-Ges. No. 299,306. Oct. 22, 1927.

Process for the manufacture of weldless tubular metallic pieces closed at one end and bulged or ornamented. Christofle et Cie. No. 301,417. Nov. 29, 1927.

Protection of metallic surfaces from corrosion. S. O. Cowper-Coles, L. Taylor, A. A. Gould and P. G. Lucas. No. 322,296. Oct. 26, 1928.

Machinery for use more particularly in the manufacture of tinplates and the like. R. Thomas & Co., Ltd. and D. H. Davies. No. 322,300. Nov. 1, 1928.

Electric furnaces. F. B. Woolford. No. 322,367. Dec. 24, 1928.

Rapidly producing uniform metal deposits electrolytically. K. Breusing and U. Gottesmann. No. 322,371. Dec. 28, 1928.

Canadian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Apparatus for casting hollow bodies. A. Keup, W. Koehn and J. Beckmann, all of Gelsenkirchen, Germany. No. 294,198. Nov. 6, 1928.

Metal casting machine. The American Smelting and Refining Company, New York, N. Y., assignee of H. C. Poske, El Paso, Texas. No. 294,-271. Feb. 16, 1928.

Classification system for pulverized materials. The Hardinge Co., Inc., assignee of H. Hardinge, both of York, Pa. No. 294,312. Nov. 29, 1926.

Die and stamping method. The Henry B. Newhall Corporation, Garwood, N. J., assignee of H. W. Pleister, Westfield, N. J. and J. Karitzky, Garwood, N. J. No. 294,331. Sept. 4, 1928.

Process and apparatus for coating articles. The Ohio Brass Co., assignee of P. J. Kelley, both of Mansfield, Ohio. No. 294,333. Oct. 1, 1928.

Process and apparatus for coating articles. The Ohio Brass Co., assignee of P. J. Kelley, both of Mansfield, Ohio. No. 294,334. May 16, 1929.

Apparatus for molding engine sleeves. The Superior Foundry Co., Cleveland, Ohio, assignee of R. R. Shaw, Chicago, Ill. No. 249,349. Oct. 22, 1927.

Production of ore briquettes. E. A. A. Grönwall, Stockholm, Sweden. No. 295,271. June 22, 1928.

Process of reconditioning iron and steel. R. C. Heinzmann, Cincinnati, Ohio. No. 295,278. Apr. 12, 1929.

Gold or mineral trap. J. M. Kirkpatrick, Huntingdon Valley, Pa. No. 295,286. Nov. 8, 1928.

Untinning method. Q. Marino, Yerre, Seine-et-Oise, France. No. 295,292. Feb. 25, 1928.

Method of protecting wood and other substances. P. W. Turner, Ada, Ohio. No. 295,324. Jan. 2, 1919.

Method of forming irregular sheet metal stampings. The Edward G. Budd Manufacturing Co., assignee of W. J. Meinel, both of Philadelphia, Pa. No. 295,341. Dec. 4, 1928.

Process for decomposing ores of the rare earths of zirconium and titanium by sulphuric acid. Deutsche Gasglühlicht-Auer-Gesellschaft m.b.H., assignee of J. D'Ans, both of Berlin, Germany. No. 295,359. May 11, 1928.

Process for joining together metal surfaces. (Application of molten metal between strips of amalgamated metal.) The Expanded Metal Co., Ltd., Westminster, assignee of W. Smith, West Hartlepool, England. No. 295,369. Feb. 19, 1929.

Electrical resistance element. The Globar Corporation, Niagara Falls, N. Y., assignee of Société Anonyme Kummler & Mattes, assignee of F. Eichenberger, both of Aarau, Switzerland. No. 295,375. Aug. 9, 1923.

Electrical resistance element. The Globar Corporation, Niagara Falls, N. Y., assignee of Société Anonyme Kummler & Mattes, assigne of F. Eichenberger, both of Aarau, Switzerland. No. 295,376. June 4, 1925.

Metallized element. The Globar Corporation, Niagara Falls, N. Y., assignee of Société Anonyme Kummler & Mattes, assignee of F. Eichenberger, both of Aarau, Switzerland. No. 295,377. June 4, 1925.

Wire drawing machine. The Union Drawn Steel Co., Beaver Falls, Pa., assignee of J. T. Leech, Beaver, Pa. No. 295,405. Dec. 17, 1928.

Vanadium-aluminum-silicon alloy. The Vanadium Corporation of America, Bridgeville, Pa., assignee of B. D. Saklatwalla, Crafton, Pa. No. 295,406. Jan. 14, 1929.

Vanadium-aluminum-silicon alloy. The Vanadium Corporation of America, Bridgeville, Pa., assignee of B. D. Saklatwalla, Crafton, Pa. No. 295,407. July 16, 1929.

Process of manganese ore treatment. J. C. Wiarda & Co., Brooklyn, N. Y., assignee of N. A. Laury, Rockville Center, Long Island, N. Y. No. 295,409. Feb. 19, 1927.

Continuous annealing and heat treating furnace. A. T. Kathner, New Cumberland, W. Va. No. 295,425. Apr. 16, 1928.

Method of decomposing a carbonate or reducing an oxide. G. Patart, Paris, France and H. Nielsen, Bromley, Kent, England. No. 295,434. Dec. 8, 1928.

Process of coating metals. B. Jirotka, Berlin, Germany. No. 295,468. July 17, 1929.

Electric welding machine. W. E. Reed, Pittsburgh, Pa. No. 295,485. Nov. 13, 1928.

Roll grinding machine. H. R. Williams, New York, N. Y. No. 295,507. Feb. 1, 1929.

Compressed compositions. (*Copper, tin and zinc, with or without graphite.*) The Bound Brook Oil-less Bearing Co., Bound Brook, N. J., assignee of C. Claus, Plainfield, N. J. No. 295,514. Jan. 28, 1927.

Drawing ring for wire-drawing machines. Drahtindustrie Peter Darmstadt & Co., G.m.b.H., Frankfurt a.M., assignee of P. Darmstadt, W. Stegman and V. Weil, all of Fechenheim, near Frankfurt a.M., Germany No. 295,548. July 4, 1928.

Centrifugal casting machine. The Sand Spun Patents Corporation, Wilmington, Del., assignee of W. D. Moore and W. Morgan, both of Birmingham, Ala. No. 295,594. June 18, 1928.

Process for the treatment of oxidic raw materials. The International Patent Corporation, Baltimore, Md., assignee of T. R. Haglund, Stockholm, Sweden. No. 295,631. June 22, 1928.

Danish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Welding machine for radiator elements and the like. Svenska Aktiebolag Gasaccumulator, Stockholm, Sweden. No. 41,009. Dec. 3, 1927.

Electric resistance material, consisting of a refractory workable alloy. H. G. A. von Kantzow, Hallstahammar, Sweden. No. 41,169. June 19, 1928.

Process and apparatus for the production of ferrous alloys which are free from gases, especially oxygen. C. Brackelsberg, Milspe, Westfalen, Germany. No. 41,179. Dec. 20, 1928.

Magnetic material. Electrical Research Products, Inc., New York, N. Y. No. 41,203. July 29, 1926.

Process for producing a coating on iron and steel objects. Société Continentale Parker, Clichy, France. No. 41,259. Dec. 21, 1928.

French Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Improvements to means for heating and cooling lead presses. Felten & Guilleaume Carlswerk Akt.-Ges. No. 674,708. May 7, 1929.

Improvement in the treatment of ores, metallurgical products, residues and the like, for the recovery of metals of the platinum group. Johnson-Mathey & Co. No. 674,312. Apr. 30, 1929.

Process for making an alloy consisting of a carbide of tungsten or molybdenum and a metal or metalloid having a lower melting point. Fried. Krupp Akt.-Ges. No. 674,335. May 1, 1929.

Bronze having a high content of white iron and process for making it. L. Guichard. No. 674,375. Sept. 12, 1928.

Metallurgical product and process for making it. Société Phosphates & Superphosphates de Thebaka. No. 674,389. Sept. 13, 1928.

Improvements to furnaces and (or) apparatus for annealing and heat treating metals and other products. A. Smallwood and J. Fallon. No. 674,654. May 6, 1929.

Process for precipitating metals on an incandescent body. N. V. Philips, Gloeilampenfabrieken. No. 674,711. May 7, 1929.

Process for treating oxidic iron ores. W. S. Millar. No. 674,715. May 7, 1929.

Electric soldering iron. Mlle. M. C. A. Textor. No. 674,373. Sept. 11, 1928.

Process for welding chain links. K. Huppelshauser. No. 674,448. May 2, 1929.

Process for casting hollow thin-walled bodies. Vereinigte Stahlwerke Akt.-Ges. No. 674,630. May 6, 1929.

Process for precipitating metals on an incandescent body. N. V. Philips, Gloeilampenfabrieken. No. 674,663. May 6, 1929.

Machine for making crank shafts. Atlas Drop Forge Co. No. 674,678. May 8, 1929.

Process and apparatus for working metal in the form of bars or tubing. Pipe and Tube Bending Corporation of America. No. 674,771. May 8, 1929.

Improvements to electro-plating processes. Société Anonyme de Perfectionnements Electrolytiques. No. 674,411. Sept. 18, 1929.

Device for obtaining electrolytic deposits on hollow objects. Société Anonyme de Perfectionnements Electrolytiques. No. 674,419. Sept. 19, 1928.

Device for the discharge and recovery of vapors from chemical treatment baths electrolytic or otherwise. Société Anonyme de Perfectionnements Electrolytiques. No. 674,420. Sept. 19, 1928.

Process of electrolysis. U. C. Tainton. No. 674,467. May 2, 1929.

Process for the electrolytic separation of heavy metals. M. Schlotter. No. 674,490. May 2, 1929.

Process for the electrolytic chromium plating of various objects in a bath in an oscillating tank. Albert Bietziger Verchromungs-Anlagen. No. 674,586. May 4, 1929.

Process for obtaining metallic carbonyls. I. G. Farbenindustrie Akt.-Ges. No. 674,458. May 2, 1929.

Process for bonding different metals. The Cleveland Graphite Bronze Co. No. 674,882. May 10, 1929.

Process and apparatus for continuous annealing in a reducing atmosphere inside of closed containers. Société en Commandite H. Schaefer & Cie. No. 674,926. May 11, 1929.

Device for heating a molten mass of metal or alloy, particularly steel in a casting ladle. Fried. Krupp Akt.-Ges. No. 674,978. May 13, 1929.

Improvements to rolling mills. Société Anonyme des Anciens Etablissements Chavanne-Brun Frères. No. 675,000. May 13, 1929.

Process for the separation of two materials of different densities. Société des Mines de Pied-Selle. No. 675,096. Oct. 2, 1928.

Process for reducing metals from their ores. E. A. A. Grönwall and H. J. H. Nathorst. No. 675,189. May 15, 1929.

Process for the heat treatment of metals, alloys, and objects made of these materials. G. Schoenberg. No. 675,226. May 15, 1929.

Improvements to refractory materials. F. W. Berk and Co., Ltd. No. 675,238. May 16, 1929.

Process for the electrolytic recovery of tin from stannate or alkaline stannite lixivia. Siemens & Halske Akt.-Ges. No. 675,240. May 16, 1929.

Improvements to automatic precision draw-plates. Société Anonyme des Ateliers Bariquand & Marre. No. 674,856. Sept. 25, 1928.

Regulating device for automatic arc welding machines. R. Sarazin. No. 674,875. May 10, 1929.

Apparatus for conditioning molding sand or similar materials. Royer Foundry and Machine Co. No. 674,935. May 11, 1929.

Casting ladle. Fried. Krupp Akt.-Ges. No. 674,979. May 13, 1929.

New product for cleaning and preserving metallic elements. G. Perrone. No. 675,063. May 15, 1929.

Solder for aluminum and its alloys. J. F. Lenssens. No. 675,115. Oct. 5, 1928.

Cleaning powder for all metals. R. Griette. No. 675,148. Oct. 12, 1928.

Improved process for producing malleable metallic pipes. E. Weir. No. 675,259. May 16, 1929.

Improvements in the fabrication of malleable metallic pipes from hollow blanks. E. Weir. No. 675,260. May 16, 1929.

Improvements in the fabrication of malleable metal pipes. E. Weir. No. 675,261. May 16, 1929.

Improved process for the fabrication of malleable metal pipes. E. Weir. No. 675,262. May 16, 1929.

Cutting and welding machine. Akt.-Ges. für Tiefbohrtechnik und Maschinenbau vormals Trauzl & Co. No. 675,273. May 16, 1929.

Automatic compensator for the temperature of the cold junction of thermoelectric pyrometers. Société Française Arnoux, Veuve Chauvin & Cie. No. 675,144. Oct. 10, 1928.

Device applicable to electroplating tanks. Société Anonyme de Perfectionnements Electrolytiques. No. 675,858. Sept. 25, 1928.

Improvements in the control of the power factor and voltage of electric induction furnaces. Associated Electric Industries, Ltd. No. 674,949. May 11, 1929.

Process and device for the bottom casting of ingots, blooms, and the like. T. Brinkmann. No. 675,350. May 17, 1929.

Rolling mill. R. Michel. No. 675,351. May 17, 1929.

Crucible for use in aluminothermy. H. Schultz. No. 675,379. May 18, 1929.

Process for making pipes and other castings, flask and molding machine suitable for working this process. E. Moussiaux. No. 675,254. May 21, 1929.

Nitrogenized steel alloy having great resistance to high pressure and shocks. Fried. Krupp Akt.-Ges. No. 675,603. May 23, 1929.

Process for eliminating injurious constituents, such as phosphorus and sulphur, from pig iron without oxidizing the carbon contained in the pig iron. Fried. Krupp Akt.-Ges. No. 675,604. May 23, 1929.

Process for the production of ferrous alloys from pulverized raw materials. I. G. Farbenindustrie Akt.-Ges. No. 675,666. May 24, 1929.

Process and means for rolling thin sheets. Doubs. No. 675,446. May 21, 1929.

Improvements to electric soldering irons. H. Monteils. No. 675,486. May 22, 1929.

Two-part chaplets having inclined bearing surfaces. E. Sonnet. No. 675,678. May 24, 1929.

System of connections for electric arc welding. "Elin" Akt.-Ges. für Elektrische Industrie. No. 675,684. May 24, 1929.

Process and machine for upsetting the ends of tubes. Mannesmannröhren Werke. No. 675,731. May 25, 1929.

Improvements to large castings, such as frames for railroad rolling stock. N. Leonard. Addition Patent No. 35,743. (First addition to No. 659,217). Aug. 8, 1928.

Method of working electric annealing furnaces. Société Anonyme Brown, Boveri & Cie. No. 675,385. Sept. 26, 1927.

Method of melting or heating material in an electric furnace and furnace therefor. K. G. Wennerstrom. No. 675,452. May 21, 1929.

Improvements to anodes for chromium plating and galvanoplasty in general. S. Dreyfus. No. 675,754. May 24, 1929.

Substances to be added to acid baths for iron and steel. Verein für Chemische und Metallurgische Produktion. No. 675,828. May 27, 1929.

Improvements to electric furnaces. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. No. 675,833. May 28, 1929.

Mold and process for casting steel. Gebr. Lungen G.m.b.H. No. 675,908. May 29, 1929.

Casting ladle. Ferric Engineering Co. No. 676,012. May 31, 1929.

Process for recovering tin from tinplate scrap. L. Ughetti La Corsa. No. 676,019. May 31, 1929.

Electrolytic cell for the separation of the tin contained in solutions of tin salts. L. Ughetti La Corsa. No. 676,117. June 3, 1929.

Improvement in the internal heating of ore reduction chambers and other furnaces. H. E. Coley. No. 676,180. June 4, 1929.

Operating method, applicable to blast furnaces. F. Heyd. No. 676,196. June 5, 1929.

Process for making seamless forged vessels for high pressure applications, for example, for steam and water separators. Fried. Krupp Akt.-Ges. No. 675,951. May 30, 1929.

Process and installation for making tubing. Société Anonyme des Hauts Fourneaux & Fonderies de Pont-à-Mousson. No. 675,965. May 30, 1929.

New process and installation, applicable to the fabrication of tubing. Société Anonyme des Hauts Fourneaux & Fonderies de Pont-à-Mousson. No. 675,966. May 30, 1929.

Improvements to the process and installations for the fabrication of tubing. Société Anonyme des Hauts Fourneaux & Fonderies de Pont-à-Mousson. No. 675,967. May 30, 1929.

Improvement to hoppers for filling foundry flasks. Société Anonyme des Anciens Etablissements Glaenzer & Perreaud & G. P. Rembourg. No. 675,970. May 30, 1929.

Preparation and application of agents for pickling metals. Société pour l'Industrie Chimique à Bale. No. 676,096. June 3, 1929.

Improvements to die-casting machines. A. C. Spark Plug Co. No. 676,110. June 3, 1929.

Improvements to electric induction furnaces. E. F. Northrup. No. 675,969. May 30, 1929.

Electric heating resistance for obtaining high temperatures. F. Neumann. No. 676,004. May 31, 1929.

German Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for the froth flotation of ores, coal and similar substances. T. Franz, Bochum-Riemke, Germany. No. 487,587. Oct. 4, 1924.

Modification of roller beds with floating rollers. Maschinenfabrik Sack G.m.b.H., Düsseldorf-Rath, Germany. No. 487,772. Jan. 26, 1928.

Revolving element for multiple-die stamping presses. E. Dietrich, Altenburg, Thüringia, Germany. No. 487,520. June 2, 1928.

Process for making supporting elements for welded sheet radiators. Böttiger & Co., Biebesheim a.Rh., Germany. No. 487,521. Nov. 26, 1927.

Tire-rolling mill. Demag Akt.-Ges., Duisburg, Germany. No. 487,717 (Addition to No. 460,410). Feb. 27, 1925.

Process for the reduction of ores, especially iron ores, in a tunnel furnace. Nybergs Grufaktiebolag, Smedjebacken, Sweden. No. 487,537. Feb. 8, 1927.

Process for the production of copper-bearing cast iron and steel. Fr. Heusler, Dillenburg, Germany. No. 487,538. Aug. 21, 1928.

Bright-annealing process, especially for metals which are difficult to bright-anneal. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemensstadt, Germany. No. 487,729. June 13, 1926.

Charging device for industrial furnace installations. Hirsch, Kupfer- und Messingwerke Akt.-Ges., Berlin, Germany. No. 487,599. Oct. 28, 1927.

Reduction of ores. H. Wittek, Beuthen, O.S., Germany. No. 487,560. July 27, 1926.

Process for preventing the inner lining of electrolytic tanks containing hygroscopic fused anhydrous salts, from absorbing water. A. C. Jessup, Clamart, Seine, France. No. 487,815. Nov. 25, 1928.

Process for the production of aluminum alloys. T. R. Haglund, Stockholm, Sweden. No. 487,584. May 13, 1925; in Sweden, Nov. 15, 1924.

Method and device used in working continuous electrolytic processes. Langbein-Pfanhauser-Werke, Akt.-Ges., Leipzig, Germany. No. 487,680. (Addition to No. 483,313). Mar. 20, 1929.

Process for coloring aluminum and its alloys. A. Pacz, Cleveland, Ohio. No. 487,754. Jan 19, 1929.

Process and apparatus for separating ore from gangue with addition of fine, metal-free sand. S. Podiakonoff, Moscow, U. S. S. R. No. 488,092. Dec. 20, 1924.

Roll for hot-rolling iron and other metals. S. Junghans, Villingen, Baden and F. Grah, Hemer, Westfalen, Germany. No. 488,153. Nov. 24, 1927.

Drive for rolling mills. Mitteldeutsche Stahlwerke Akt.-Ges., Berlin, Germany. No. 488,098. Nov. 18, 1928.

Mill for rolling balls. O. Hering, Essen-Bredeney, Germany. No. 488,024. (Addition to Patent No. 485,767.) Apr. 28, 1928.

Process for the direct production in the electric furnace of ingot iron or steel, or other metals and alloys which combine with carbon. No. 487,875. (Addition to Patent No. 461,746.) Nov. 13, 1925; in Sweden, Nov. 19, 1924.

Apparatus for the preparation of molding sand. Badische Maschinenfabrik & Eisengiesserei vormals G. Sebold und Sebold & Neff, Durlach, Baden, Germany. No. 488,124. Nov. 25, 1928.

Method of and device for making molds with the use of a moldboard. J. Last, St. Regulus, England. No. 488,125. Jan. 8, 1927; in Great Britian, Nov. 22, 1926.

Production of metals and metallic compounds which are soluble in ammoniacal liquors. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 488,087. Apr. 28, 1927.

Gas-tight closure for rotating furnaces and drums. C. P. Debuch, Bochum, Germany. No. 488,166. Feb. 13, 1926.

Composite material. Kaiser-Wilhelm-Institut für Eisenforschung e.V.r Düsseldorf, Germany. No. 488,209. June 24, 1928.

Malleable nickel-tin-copper alloy. R. Ozlberger, Vienna, Austria. No. 488,-048. Mar. 30, 1927; in Austria, Apr. 3, 1926.

Method of testing the properties of the materials composing elongated magnetizable bodies. Neufeldt & Kuhnke G.m.b.H., Kiel, Germany. No. 487,-856. July 9, 1925.

Ingot shear with crank drive and movable upper blade. Maschinenfabrik Froriep G.m.b.H , Rheydt, Rheinland, Germany. No. 488,224. July 2, 1927

Forging machine. Schiess-Defries Akt.-Ges. Düsseldorf, Germany. No. 487,905. Aug. 30, 1928

Welding machine for radiators and the like. Svenska Aktiebolaget Gasaccumulator, Stockholm, Sweden. No. 487,906. July 8, 1928.

Torch chutting machine. A. Godfrey, London, England. No. 487,907. Mar. 19, 1925; in Great Britain, July 15, 1924 and Feb. 24, 1925.

Production of razor blades. Kamphausen & Plümacher G.m.b.H., Ohligs. Rheinland, Germany. No. 487,908. Dec. 16, 1928.

Mill for rolling balls. A. Putsch, Kupferdreh, Germany. No. 488,359. July 9, 1926.

Method and device for cooling closure devices in hot gas lines, especially hot blast valves, with the aid of circulating cooling water. A. Borchardt, Hamborn, a.Rh., Germany. No. 488,614. May 4, 1926.

Process for the direct production of metal, especially sponge iron, from ores or other metalliferous materials, using a rotary furnace. T. Rowlands, Sheffield, England. No. 488,615. May 3, 1928.

Reversible regenerative metallurgical furnace. B. Talbot, Middlesbrough, England. No. 488,529. July 6, 1927.

Method of uniformly heating metals or similar materials and of maintaining a uniform temperature by circulation of a current of hot gas. Reischach & Co. G.m.b.H., Berlin, Germany. No. 488,450. Jan. 1, 1926.

Quaternary magnetic alloy for telegraph and telephone conductors, which is practically free from carbon and is composed of iron and nickel, either silicon or aluminum for the third element and a fourth element. W. S. Smith, Newton Poppleford, H. J. Garnett, Sevenoaks, and J. A. Holden, Gidea Park, England. No. 488,288. Nov. 6, 1927; in Great Britain Nov. 6, and Dec. 17, 1926.

Electric furnace for heating metallic objects. Siemens-Schuckertwerke Akt. Ges., Berlin-Siemensstadt, Germany. No. 488,289. July 12, 1925; in the United States July 11, 1924.

Industrial furnace, particularly electrically heated ones. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 488,290. May 11, 1927.

Charging melting furnaces. W. E. Naylor, Chicago, Ill. No. 488,634. Sept. 11, 1927; in the United States, Feb. 5, 1927.

Working up liquors used to leach roasted pyrites and similar ores and recovery of the metals contained in the liquors. C. Schantz, Berlin, Germany. No. 488,582. Mar. 1, 1925.

Process for making compressing objects out of the powder of metals which are suitable for making bearings and current collectors. Hartstoff-Metall Akt.-Ges. (Hametag), Berlin-Cöpenick, Germany. No. 488,583. Mar. 24, 1925.

Process for the electrolytic refining of aluminum alloys. Aluminum Company of America, Pittsburgh, Pa. No. 488,584. Dec. 21, 1923; in the United States, Dec. 21, 1922.

Process for the direct working up of electrolytically produced copper. W. Tirre, Bremen, Germany. No. 488,585. June 7, 1925.

Production of ductile chromium. Westinghouse Lamp Company, Bloomfield, N. J. No. 488,472. June 25, 1925.

Process for protecting iron and steel objects with the aid of a plating of chromium. Metals Protection Corporation, Indianapolis, Ind. No. 488,586. Mar. 20, 1926.

Pickling installation with several pickling tanks. Demag Akt.-Ges., Duisburg, Germany. No. 488,508. May 28, 1925.

Process for producing coatings on light metals. Dr. Otto Sprenger Patentverwertung Jirotka m.b.H., Vaduz, Liechtenstein. No. 488,554 (Addition to Patent No. 475,789.) July 26, 1927.

Italian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Electromagnetic method of subterranean exploration. Barzano & Zanardo, Milan, Italy. No. 263,304. (Importation of French Patent No. 545, 590.) Dec. 9, 1927.

Furnace for continuous bright-annealing in a gaseous atmosphere. Akt.-Ges. Brown, Boveri & Cie., Baden, Switzerland. No. 263,470. Dec. 23, 1927, in Germany, Dec. 27, 1926.

Process for extracting aluminum from clay. Elektrizitätswerk Lonza, Gampel, Valais, Switzerland. No. 263,130. Sept 13, 1927; in Germany, Sept. 18, 1926. (In the name of Metallbank und Metallurgische Gesellschaft.)

Malleable nickel-molybdenum-chromium alloy. T. D. Kelley, London, England. No. 263,088. Aug. 30, 1927.

Improvements to alloys. T. D. Kelley, London, England. No. 263,322. Aug. 23, 1927; in Great Britain, Sept. 4, 1926. (British Patent No. 264,414.)

Improvements to alloys. T. D. Kelley, London, England. No. 263,380. Sept. 6, 1927; in Great Britain, Sept. 22, 1926. (British Patent No. 270,553.)

Sintered hard metal alloy and objects made out of the same. F. Krupp Akt.-Ges., Essen, Germany. No. 263,265. Oct. 18, 1927.

Sintered hard metal alloy and objects made thereof. F. Krupp Akt.-Ges., Essen, Germany. No. 263,266. Oct. 18, 1927.

Process for tempering iron and the like by means of gases developed in the tempering furnace. H. Lindhorst, Berlin-Grünewald, Germany. No. 263,345. Aug. 31, 1927.

Alloy for tools and dies. Società Edison-Clerici, Fabrica Lampade, Milan, Italy. No. 263,136. Oct. 17, 1927; in the United States, Oct. 22, 1926. (In the name of W. P. Sykes.)

Process for ductilizing sheet iron, rolled aluminum by heating to red heat. Eisen- u. Stahlwerk Hoesch, Akt.-Ges., Dortmund, Germany. No. 263,449. Nov. 10, 1927.

Machine for rolling metal wire. Maschinenfabrik Akt.-Ges. Richard Herz-Vienna, Austria. No. 263,559. Oct. 31, 1927; in Austria, Nov. 3, 1926. (In the name of O. Stern and A. Lukas.)

Molding machine. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemens, stadt, Germany. No. 263,129. Aug. 31, 1927; in Germany, Sept. 2, 1926.

Improvements to processes for stamping and drawing metals. Toledo Machine and Tool Company, Toledo, Ohio. No. 263,331. Jan. 26, 1927.

Process for welding chain links and the like. J. Venz, J. Alvera and G. Brunhübner, Pforzheim, Germany. No. 263,324. Aug. 20, 1927.

Improvements to electric furnaces. H. George, Paris, France. No. 263,257. Oct. 19, 1927; in France, Sept. 27, 1926.

Improvements to electric furnaces. Société Electrométallurgique de Montricher, Paris, France. No. 263,302. Dec. 17, 1927; in France, Dec. 21, 1926.

Improvements to electric furnaces. Société Electrométallurgique de Montricher, Paris, France. No. 263,303. Dec. 17, 1927; in France, Dec. 28, 1926.

Swedish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Mounting of arc furnace electrodes. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 68,670. Aug. 30, 1926; abroad Oct. 9, 1925 and Jan 10, 1926

Process for the production of hard metal. E. A. A. Grönwall, Stockholm, and S. G. Lind, Arboga, Sweden. No. 68,675. Oct. 9, 1928.

Mandrel structure for rolling mills. Mannesmannröhren-Werke, Düsseldorf, Germany. No. 68,689. Sept. 5, 1927; abroad June 14, 1927.

Carbon electrode for electric furnaces. C. W. Becher, Dobrava, Jugoslavia. No. 68,733. May 29, 1926; abroad June 2, 1925.

Reviews of Manufacturers' Literature

In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment, should be of interest to the readers of METALS & ALLOYS. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* METALS & ALLOYS *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department.*—EDITOR.

Rolled Zinc.—A 54-page booklet assembling the various facts pertaining to zinc in wrought form, particularly rolled zinc. Intended primarily as a reference book. Contains a chapter on metallography, Bibliographic notes. Physical and chemical constants. Instructions as to finishing methods and a thorough index. Compiled by the staff of the Metal Section Research Division, The New Jersey Zinc Company. New Jersey Zinc Company, 160 Front Street, New York, N. Y.

Copper Sheet Steel.—This new 16-page booklet is entitled "The Testimony of Science and Service." Large charts graphically representing the atmospheric corrosion tests of the American Society for Testing Materials since 1916 are included. American Sheet and Tin Plate Company, Frick Building, Pittsburgh, Pa.

Other booklets issued by the same company, "Apollo Best Bloom and Apollo-Keystone Galvanized Sheets," "Black Sheets and Special Sheets," "Better Buildings," "Special Sheets for Electrical Apparatus," "Copper Steel Roofing Tin," "Bright Tin Plates," "The Evolution of a Tin Can," "Corrugated Galvanized-Concrete Fence," "Research on the Corrosion Resistance of Copper Steel," "The Influence of Very Low Percentages of Copper, in Retarding the Corrosion of Steel," "Observations Upon the Atmospheric Corrosion of Commercial Sheet Iron," "Facts Simply and Briefly Told," "Reducing the Corrosion in Steel Cars," "Protection of Iron and Steel Sheets Against Rusting," "Rustproofing of Steel Materials," "A Summary of the Conclusions of the Scientists" and "Anti-Corrosive Metal."

Spectroscopy.—An 18-page booklet entitled "The Detection and Investigation of Poisons by Spectroscopy," discusses the application of spectroscopy to the determination of the presence of organic and metallic poisons in food products. Adam Hilger, Ltd., 24 Rochester Place, Camden Road, London NW 1, England.

Testing Equipment.—This 62-page loose-leaf booklet gives considerable very interesting information on Southwark-Emery Testing Equipment. Arguments for and against the hydraulic testing machine are included in Section I. Section II begins with the first horizontal Emery machine built by the War Department at the Watertown Arsenal in 1875 and traces the development of the company in a brief historical sketch. The Emery weighing system, dial indicator and loading system are covered in some detail. For recording either the recorder of the Brown Instrument Company or the Leeds & Northrup Company can be used. Design, installation, maintenance and calibration are covered. Various models are illustrated. Southwark Foundry & Machine Co., 400 Washington Ave., Philadelphia, Pa.

Tycos Rochester.—The January 1930 issue of this publication contains the following very interesting articles: Science Surveys the Snows; Overcoming Greatest Foe to Aviation; Airmail Pilots no Longer at Mercy of Weather Elements; Our Regions of Deepest Snowfall and The Hygrometer in Home and Industry. Taylor Instrument Companies, Rochester, N. Y.

Electric Furnaces.—An attractive booklet of 16 pages, describes various types of electric furnaces used for such purposes as heat treating, steel annealing and hardening aluminum and other non-ferrous alloys, vitreous enameling, etc. Illustrated. Falls Electric Furnace Corp., 660 Grant St., Buffalo, N. Y.

Automotive Springs.—A handsome booklet of 39 pages dis[illegible]es the general problem of special steels for automotive springs with particu[illegible]ar emphasis on Chrome-Vanadium Steel. Contains standard specifications and tests. Illustrated. Vanadium Corp. of America, 120 Broadway, New York, N. Y.

The Spiral Stripe.—No. 10 of a bulletin issued at regular intervals giving information as to the use of wrought iron in various industrial and architectural applications. This issue presents interesting data as to use of wrought iron pipe in one of the largest rayon plants and in a modern oil refinery. Illustrated. A. M. Byers Company, Pittsburgh, Pa.

Temperature Control in Steel Treating.—An int[illegible]esting booklet entitled "Problems and Practices of Modern Steel Treating" gives an illustrated review of current methods and indicates the types of temperature indicating or recording equipment most suitable for each. Deals with such important processes as annealing, normalizing, drawing and tempering, hardening, patenting wire, carburizing, cyaniding, galvanizing, sherardizing, tinning, chromium plating, hydrogen copper brazing, etc. The Brown Instrument Company, Wayne and Roberts Aves., Philadelphia, Pa.

Westinghouse Engineering Achievements.—A very interesting booklet of 36 pages, describes briefly the principal technical achievements of the Westinghouse organization during the past year. Of particular interest to metallurgists is the description of a portable electric furnace for nitriding in cases where it is desirable to bring the furnace to the work on account of the size or shape of the part being treated. Also an interesting account of Konel, a new, extremely hard and tough alloy of nickel, cobalt and ferrotitanium. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Leitz Catalog No. 1090.—This publication includes the entire range of Leitz Micro-objectives, Oculars, Summars and Micro-summars for metallographic investigation. A page of the publication is devoted to explaining the advantages of the various types of objectives. (Achromatic, Fluorite and Apochromatic). We believe that the list of Objectives, Oculars, etc., as indicated in the publication is the most extensive one as yet published. Magnification tables indicating various optical factors are referred to in the publication. E. Leitz, Inc., 60 E. 10th St., New York.

The Scovill Standard.—A monthly magazine giving interesting information as to the copper, brass and bronze products of this company and as to various applications of them. Scovill Manufacturing Co., Waterbury, Conn.

Butt Welding.—Leaflet describing latest types of high efficiency Butt Welding equipment. The Federal Machine & Welder Co., Warren, Ohio.

"Cloudburst" Superhardening Equipment.—This new bulletin (Bulletin No. 4) was issued for use at the recent Power Show. It gives considerable data that has never been called to the attention of metallurgists before. 6 x 9 inches. 24 pages. Tinius Olsen Testing Machine Company, Philadelphia, Pa.

Cutting Corrosion Costs.—Interesting booklet describing the application of the Gross Lead-Coating process which consists of so preparing equipment made of steel, brass, bronze, copper, etc., that it will take a permanent, firmly adherent, and flawless coating of pure soft lead. Some very interesting pieces of chemical engineering equipment are illustrated. The Gross Lead-Burning & Coating Corp., Cleveland, Ohio.

Reading Tubular Goods.—A compact 34-page pocket size booklet containing a detailed catalog of genuine wrought iron pipe and tubular products, Reading Iron Company, Reading, Pa.

Electric Heat Oven.—An attractive, well illustrated booklet of 23 pages describing in detail electrically heated equipment for drying, tempering, core baking, japanning, lacquering, armature baking and other industrial purposes. The Paul Maehler Company, 2210–16 West Lake St., Chicago, Ill.

Laboratory Furniture.—An illustrated pamphlet describing modern furniture for research and control laboratories. Also, a complete line of specialized laboratory hardware, water, gas, vacuum and air fittings, etc. Kewaunee Mfg. Co., Kewaunee, Wis.

Gas Masks.—A bulletin describing various types of gas masks suitable for industrial purposes. Bullard-Davis, Inc., 67 Wall Street, New York, N. Y.

Bonderite.—A pamphlet describing the applications and advantages of a chemical primer for paint, enamels or lacquer. Extensively used in the automotive and metal furniture industries. Parker Rust-Proof Company, 2177 E. Milwaukee Ave., Detroit, Mich.

Nickel Cast Iron.—A 12-page pamphlet giving the properties and applications of nickel and nickel chromium cast iron in the aeronautical, automotive, machine tool, power plant, railroad and other industries. The International Nickel Co., Inc., 67 Wall Street, New York, N. Y.

Fatigue Testing Equipment. Bulletin No. 1 describing the R. R. Moore Fatigue Machine for determining the resistance of metals to repeated stresses, the facts of various factors on the life of metals, and causes of service failures. The Thompson Grinder Co., Springfield, Ohio.

Pioneer Alloy Products.—Leaflet describing acid-resisting and heat-resisting valves, cocks, pump parts, and castings for the chemical, petroleum and allied industries. Pioneer Alloy Products Co., Inc., 16601–11 Euclid Ave., Cleveland, Ohio.

High Temperature Cements.—Leaflet describing where and how to use "Zero" refractory cement. Standard Fuel Engineering Co., Post Avenue S, Detroit, Mich.

Heat-resisting Practices.—Pocket size, 16-page booklet describing refractory bonding mortar for maintaining furnace walls and refractory linings in various types of metallurgical furnaces, ladles, retorts, chemical process equipment. Keystone Refractories Co., 120 Liberty St., New York, N. Y.

Rare Metals.—An informative treatise on tantalum, tungsten and molybdenum giving the history, properties and uses of these metals and describing the facilities of the Fansteel Products Company's research laboratories. Copiously illustrated. 54 pages. Fansteel Products Co., Inc., North Chicago, Ill.

Acid-resisting Material.—A pamphlet describing the construction of "Basolit" tanks for pickling, plating and storage of corrosive liquids. Nukem Products Corp., 70 Niagara Street, Buffalo, N. Y.

High Temperature Cements.—12-page booklet describing six specialized products and a spray gum for the application of refractory facings. Botfield Refractories Co., Swanson and Clymer Streets, Philadelphia, Pa.

Connersville Bulletin No. 123.—16-page bulletin describing Boston Type rotary positive blowers. Illustrated. Connersville Blower Co., Connersville, Ind.

From Steel Balls to Oil Stills.—Booklet listing many of the parts and materials being treated in the electric furnaces made by the Electric Furnace Company and showing views of furnaces, including the world's largest annealing furnace and the largest installation for handling forgings. 50 pages. The Electric Furnace Co., Salem, Ohio.

Nitralloy and the Nitriding Process.—Booklet on the subject indicated. Complete schedule of operations, equipment, a list of about 140 applications. 36 pages. Central Alloy Steel Corp., Massillon, Ohio.

Amsco Manganese Steel.—The July 4th issue of a leaflet entitled "New Applications" illustrated a number of unusual applications of Amsco Manganese Steel, Fahralloy and other Amsco alloys and products. American Manganese Steel Co., Chicago Heights, Ill.

Strong Aluminum Alloys.—Booklet in substantial binding on subject indicated. Several different alloys are described and considered. 60 pages. Aluminum Company of America, Pittsburgh, Pa.

Published by the same firm, "Aluminum Casting Alloys," Second Edition. Treatise on uses and advantages of ALCO standard alloys, general foundry principles and miscellaneous data. 36 pages.

Hump Method.—Piece No. 19 is entitled "Hardening Better Tools with Less Effort" and illustrates the use of the Hump method for the hardening of carbon-steel tools by Deere & Co. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

Nickel Steel.—Nickel Steel Data No. 14 is a reprint from the Transactions of the American Society of Mechanical Engineers entitled "The Manufacture of Nickel Steel Plate." It deals with the manufacture, rolling and inspection of steels containing between 2 and 3% of nickel and which are used in boiler construction. The physical properties of the metal are first discussed, following which details are given of its manufacture, beginning with the ingot phase and proceeding then step by step through stripping and reheating, rolling, flattening, inspecting and shearing and finally testing. The International Nickel Company, 67 Wall Street, New York, N. Y.

Electric Melting Furnace.—Bulletin GK is reprinted from a paper presented at the convention of the American Foundrymen's Association. It describes the operation of a 1½-ton per hour "Lectromelt furnace." Pittsburgh Electric Furnace Corporation, P. O. Box 1125, Pittsburgh, Pa.

Allegheny Metal.—Bulletin A describes in detail the properties of this chromium alloy in regard to resistance to several forms of corrosion and in regard to its tensile properties. Allegheny Steel Co., Brackenridge, Pa.